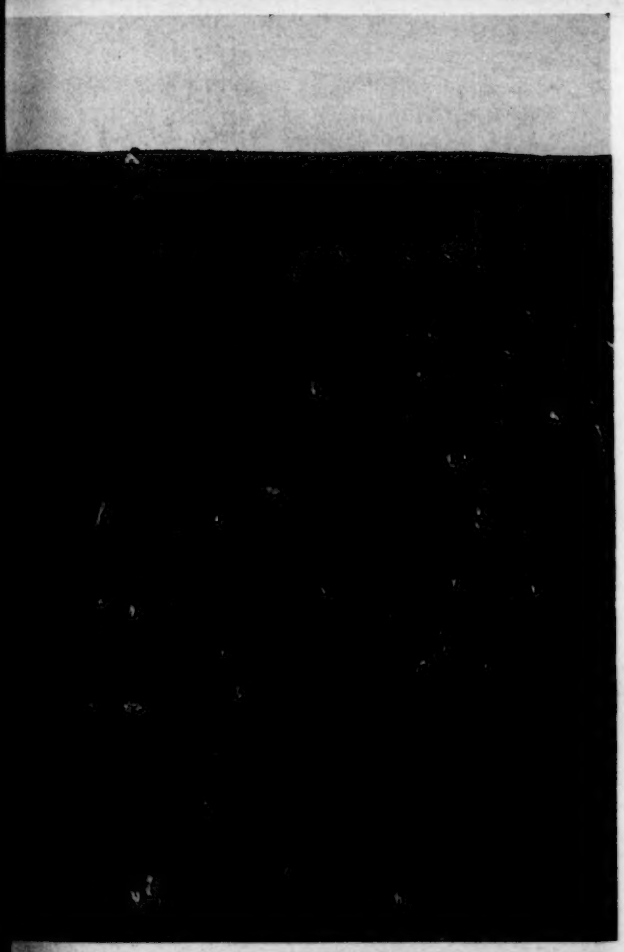

Volume 8, No. 5 September, 1953

A Program Designed to Conserve and Improve the Nation's Natural Resources
. . . DWIGHT D. EISENHOWER

A New Stage in Resources History
. . . GILBERT F. WHITE

Using Power for Soil Sampling
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Consumptive Use of Water and Irrigation Requirements
. . . WAYNE D. CRIDDLE

Watershed Management Experiments in the Colorado Front Range
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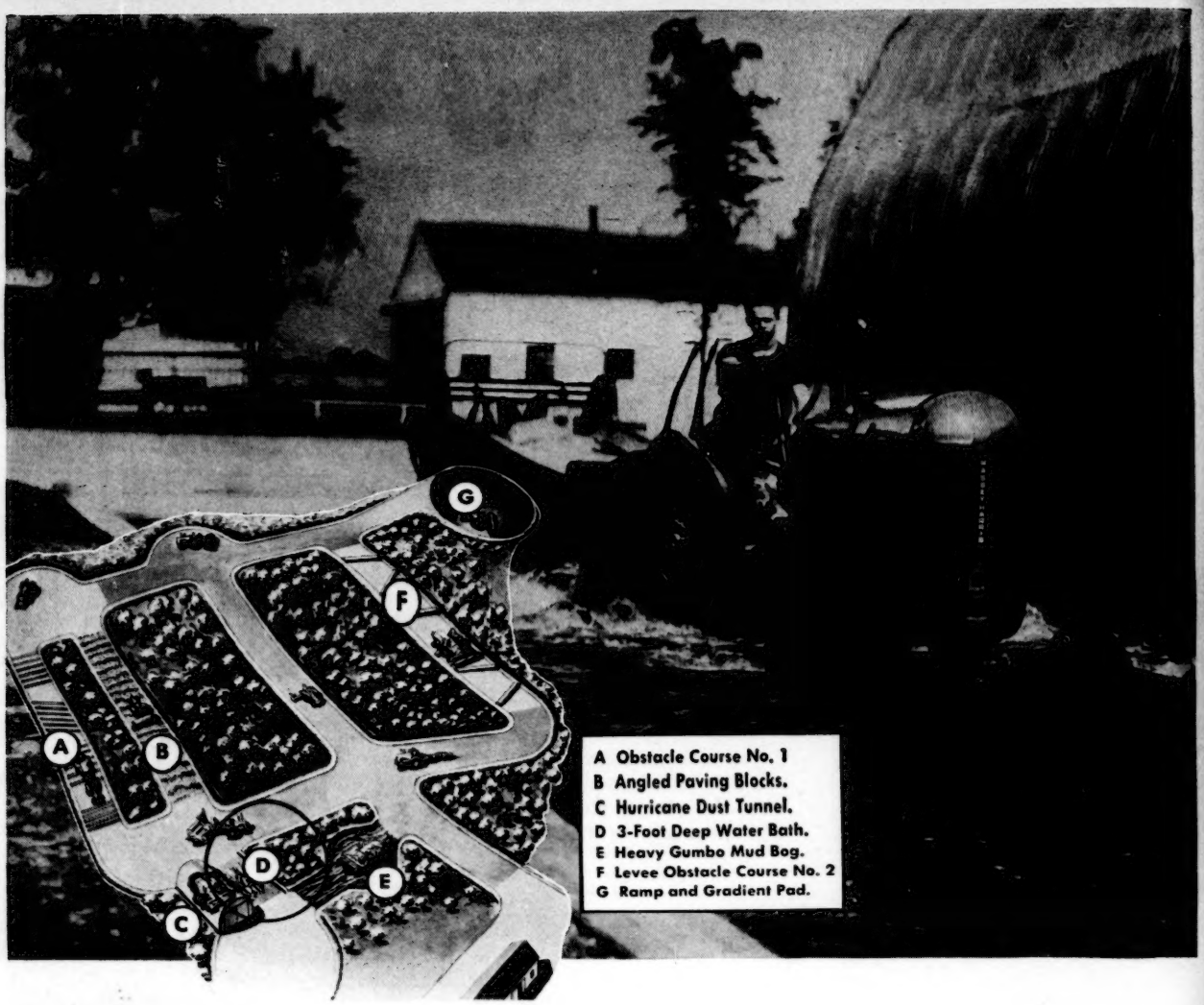
Book Reviews: Soil Science Simplified; Soil Surveys for Land Development; Climate, Vegetation and Man; World Resource Statistics.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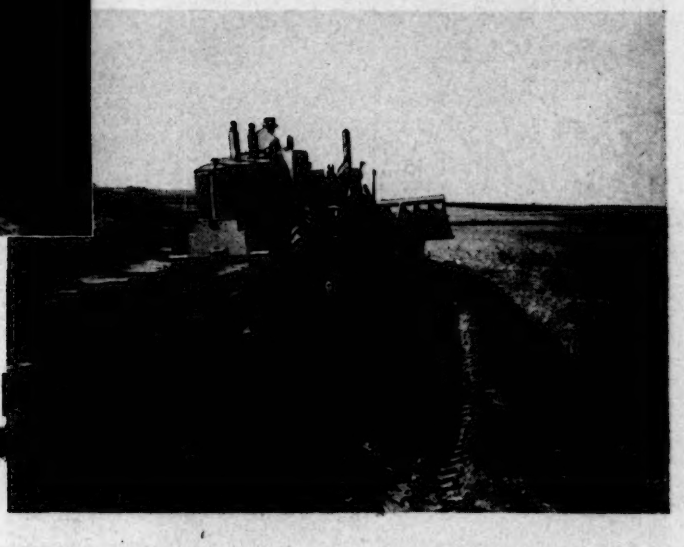

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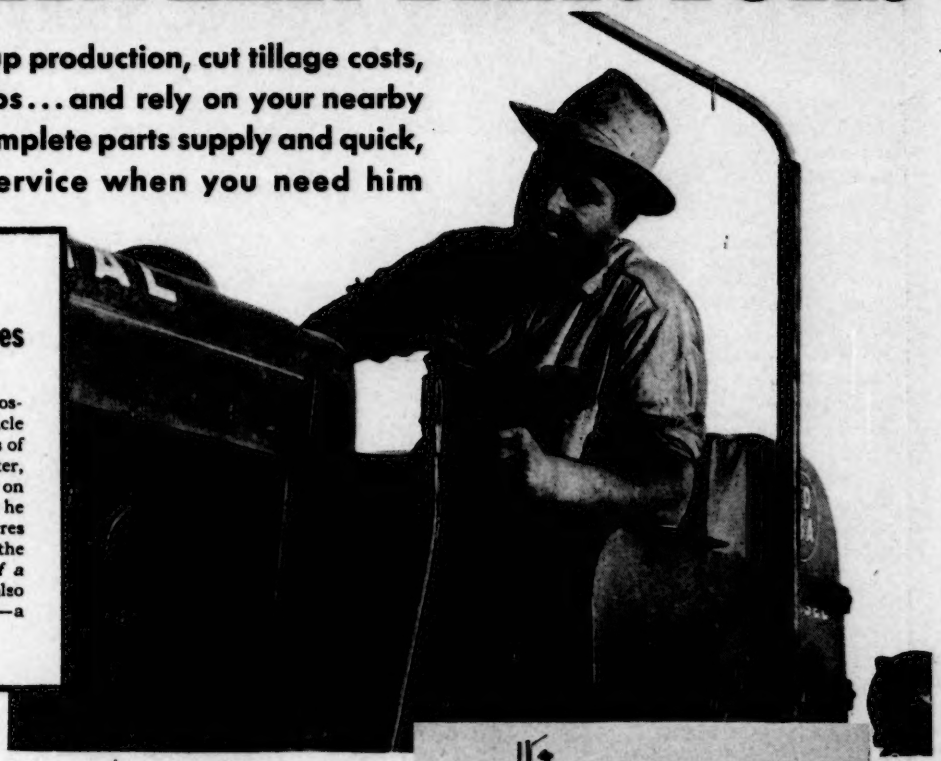

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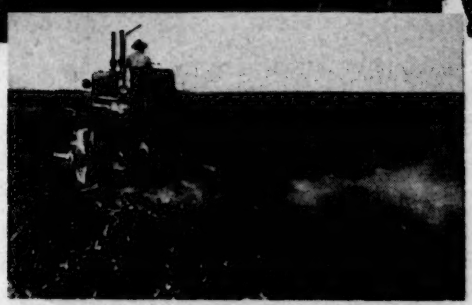

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Journal of SOIL AND WATER CONSERVATION

VOLUME 8
NUMBER 5

TO ADVANCE THE SCIENCE AND ART OF GOOD LAND USE

This JOURNAL is the official organ of the Soil Conservation Society of America. It is owned, edited, and published bi-monthly by the Society.

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Mid-Century Conference on Resources for the Future

Scheduled to be held in the Shoreham Hotel

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Lewis W. Douglas

SOIL AND WATER CONSERVATION, viewed against the broad background of conservation and development of all the nation's natural resources, will have an important place at the Mid-Century Conference on Resources for the Future scheduled in Washington, D. C., December 2 to 4.

The conference, nationwide in scope, will consider natural resources of all kinds—from minerals and water products, timber, and other raw materials to the best uses of land and water resources for living, including their recreational possibilities.

Under the Chairmanship of Lewis W. Douglas, chairman of the Board of Mutual Life Insurance Company, former Ambassador to Great Britain, and recent adviser to the President on America's foreign trade policies, this will be the most comprehensive meeting of its kind since the administration of Theodore Roosevelt, when the modern conservation movement was launched. In December, for the first time on such a large scale, conservation groups and industrial groups will be meeting together to look at the resources problem as a whole.

The nationwide meeting has been called by Resources for the Future, Inc., a non-profit corporation for research and education in the field of natural resources. The agency has received a grant from the Ford Foundation for conducting the conference.

Before his inauguration President Eisenhower stressed the importance of this new undertaking with the statement: *"It is high time that the conservation conference of 1908 should be reborn in a mid-century setting."*

It is not intended that the conference will endorse programs or come forward with a program of its own. Rather, the great contribution of this mid-century meeting can be to lay the groundwork for the adoption by others, in both public and private undertakings, of policies and programs which will safeguard and promote the national interest now and for later generations.

The key question for the conference, as phrased by Horace M. Albright, chairman of the board of Resources for the Future, Inc., is:

> ***"How can we mobilize our resource base to support the continuously expanding demands of a growing population, and assure sound economic growth and national security?"***

Rapidly maturing plans call for a lead-off session for all in attendance presided over by Robert Calkins, president of the Brookings Institution, Washington. Dr. Calkins will lead a discussion on *"The General Outlook for Resources"* along lines designed to lay the basis for more particularized discussion to follow in eight sectional meetings.

The first three sections will be of especial interest to soil and water conservationists. They are:

Section I—*Competing Demands for Use of Land*—Charles C. Colby, professor of geography, University of Chicago, Chairman, and Harry R. Wellman, dean of the College of Agriculture, University of California, Co-Chairman.

Section II—*Utilization of Land Resources*—Lloyd E. Partain, sales manager, the Curtis Publishing Company, Philadelphia, Chairman, and Samuel T. Dana emeritus of the School of Forestry and Conservation, University of Michigan, Co-Chairman.

Section III — *Water Resource Problems* — Gilbert White, president of Haverford College, Haverford, Pennsylvania, Chairman, and Abel Wolman, professor of sanitary engineering, Johns Hopkins University, Co-Chairman.

Areas assigned to additional sections are *Problems of Nonfuel Minerals, Energy Resources Problems, World Supply and Availability, Problems in Resources Research, and Patterns of Cooperation.*

A Message from

The President of the United States

Relative to

A Program Designed to Conserve and Improve the Nation's Natural Resources

Dwight D. Eisenhower

To The Congress of the United States:

In the stress of dealing with urgent problems of peace and security and budget appropriations and tax revenues, we sometimes overlook the fundamental importance to our national well-being of constructive, forward-looking policies designed to conserve and improve the Nation's natural renewable resources.

Before the Congress adjourns, therefore, I believe it will be useful to focus attention on some of our basic land and water resource problems and to point the way for constructive efforts to improve the management and use of these resources.

In my State of the Union message, I called attention to the vast importance to this nation now and in the future of our soil and water, our forests and minerals, and our wildlife resources. I indicated the need for a strong Federal program in the field of resources development. At the same time I pointed to the necessity for a cooperative partnership of the states and local communities, private citizens, and the Federal Government in carrying out a sound natural-resources program.

In addition to the immediate danger of waste resulting from inadequate conservation measures, we must bear in mind the needs of a growing population and an expanding economy. At present we are faced with excess reserves of some agricultural commodities and the need for production adjustments to gear our agricultural economy to current demands. But in the long run, we shall need to give increased attention to the improvement and reclamation of land in its broadest aspects, including soil productivity, irrigation, drainage, and the replenishing of ground-water reserves, if we are adequately to feed and clothe our people, to provide gainful employment, and to continue to improve our standard of living.

Our basic problem is to carry forward the tradition of conservation, improvement, and wise use and development of our land and water resources—a policy initiated 50 years ago under the leadership of President Theodore Roosevelt. To do this within the framework of a sound fiscal policy and in the light of defense needs will require a maximum cooperation among the states and local communities, farmers, businessmen, and other private citizens, and the federal government. It will require the development of clear guidelines to be established by the Congress as to the proper functions of the Federal Government. It will require the revitalization of renewable resources by users who should be entitled to reasonable assurances in connection with authorized uses. It will require adherence to sound principles for the financing and the sharing of the cost of multiple-purpose land and water resources development. It will require improved Federal organization to accomplish a more logical division of responsibilities among the various Federal agencies in order that resource development programs may be carried on with the greatest efficiency and the least duplication. And it will require comprehensive river basin planning with the cooperation of state and local interests.

This administration is moving ahead in the formulation of sound organization and improved policies for the use of our soil, our public lands, and our water resources. I have requested, and the Congress has granted through Reorganization Plan No. 2, increased authority for the Secretary of Agriculture to improve the organization of the Department of Agriculture. I have established by executive order a National Agricultural Advisory Commission. A review is being made of the basic power policies of the Federal Government in connection with multiple-purpose river basin development as it relates to private economic development. The Corps of Engineers is making a study of the basis for state and local financial participation in local flood-protection works. There are under detailed study various proposals for dealing with

the complicated problems of overlapping and duplicative authority among the several resource-development agencies. And the Bureau of the Budget and the resource agencies are reviewing the present standards and procedures for evaluation and cost allocation of water resource development projects.

It is fortunate that today there is a growing recognition on the part of land users and the public generally of the need to strengthen conservation in our upstream watersheds and to minimize flood damage. Inadequate conservation measures and unsound land-use patterns vastly increase the danger of loss of valuable topsoil from wind erosion in time of subnormal rainfall and from water erosion in time of floods.

This should be done as an integral part of our total flood-control and water-use program. In our past efforts to better utilize our water resources, to control floods and to prevent loss of life and property, we have made large investments on the major waterways of the nation. Yet we have tended to neglect the serious waste involved in the loss of topsoil from the nation's farms and the clogging of our streams and channels which results from erosion on the upper reaches of the small streams and tributaries of the nation's rivers.

It is important, too, for groups of farmers banded together in local organizations, such as soil-conservation districts and watershed associations, to take the initiative, with the technical advice and guidance of the appropriate Federal and state agencies in developing adequate plans for proper land use and resource improvement in watersheds throughout the nation. As these plans are prepared and local agreement and cooperation are assured, I believe that we should move ahead in the construction of works of improvement and the installation of land-treatment measures as rapidly as possible consistent with a sound overall fiscal program.

As we move forward in a cooperative and coordinated soil and water conservation program, we must not overlook the essential role played by the Federal Government in the management of public lands. Approximately 50 per cent of the land area of the western states is owned and managed by a number of Federal agencies. The National Park Service administers parks and monuments having national significance. The Forest Service administers the national forests, with their valuable timberlands and grazing resources, and in cooperation with state and local interests protects critical watersheds. The Bureau of Reclamation and the Corps of Engineers manage lands in connection with water-resource projects built by these agencies. Fish and wildlife are protected by the Fish and Wildlife Service. The Bureau of Indian Affairs administers Indian lands, and the great public domain remaining is administered by the Bureau of Land Management.

The Federal Government has a responsibility to manage wisely those public lands and forests under its jurisdiction necessary in the interest of the public as a whole. Important values exist in these lands for forest and mineral products, grazing, fish, and wildlife, and for recreation. Moreover, it is imperative to the welfare of thousands of communities and millions of acres of irrigated land that such lands be managed to protect the water supply and water quality which come from them. In the utilization of these lands, the people are entitled to expect that their timber, minerals, streams and water supply, wildlife and recreational values should be safeguarded, improved and made available not only for this but for future generations. At the same time, public lands should be made available for their best use under conditions that promote stability for communities and individuals and encourage full development of the resources involved.

While, as I have indicated, our major problem is to carry forward a tradition of improvement and conservation of our natural resources, the best means of achieving this objective depend on keeping up with changing conditions. For example, the problems of water-resource development in the west are undergoing considerable change. The pattern of western growth has broadened substantially in recent years. Industrial expansion has been extensive and varied. Increased activities in mineral and fuel processing have occurred. Urban expansion has been well above the national average in many communities. These developments have brought about strong competition for existing water supplies and have stimulated the need for a broader approach in planning new water resource developments. As a consequence, the Federal role in the cooperative development of these resources should now be reexamined in the interest of achieving a better balanced program for western growth.

Conserving and improving our land and water resources is high priority business for all of us. It is the purpose of this administration to present to the next session of the Congress suitable recommendations for achieving the objectives set forth in this message. I am confident that the studies of governmental organization and functions authorized by this Congress can also make an important contribution to the solution of these problems. As the Congress moves ahead on a constructive legislative program in the resource field, it will have my full support and cooperation. We must build a balanced program for the use and development of all our natural resources. Such a program is indispensable to maintaining and improving our standard of living as we make the future secure for a growing America.

—DWIGHT D. EISENHOWER.

The White House
July 31, 1953

Who Should Be a Member of the Soil Conservation Society of America?

R. H. MUSSER

Every professional man should be an active part of an organization which satisfies his needs for participation in the advancement of his chosen field of work. He needs the association of other men in his profession for the exchange of ideas, a medium of joint expression, a common meeting ground.

PROFESSIONAL SOIL conservationists have for many years needed a meeting ground. Their profession, unlike many scientific societies, included much more than the research aspects of their science. Too little attention had been given to the understanding and application of the findings of soil conservation research. While conservation research is essential, the need for its understanding and application by those who are going to use it is unquestioned.

The conservation of soil is everybody's business. To the farmer it means the preservation of this capital investment—his factory and plant for operations.

To the manufacturer, middleman and consumer, it means the flow of raw materials, markets for manufactured goods and a continuous supply of food and fiber.

To the scientist it is a new science, developed and recognized as such during the last two decades through sheer necessity and pioneered by an individual who for 40 years had seen the need for it. Largely through his efforts, modern soil conservation has become an American institution and has spread throughout the world.

As a science, soil conservation has two phases—the scientific phase as exemplified by the reseacher, the technician and the teacher; and the practicing phase, a part played by the farmer who owns and controls the land and who must do the job himself. It is for him that the science exists since the good that comes from it will be measured in direct proportion to its application by the farmer. A science ceases to be purposeful as long as it remains only an accumulation of systematized knowledge.

Objectives of Society Are Far Reaching

The Soil Conservation Society of America provides the meeting ground for the professional soil conservationist, the man who is active in its support and progress, and the man who applies the technology. The objective of the Society as stated in the constitution are "*. . . to promote and advance all phases of the science of conservation of soil and water resources; to provide a medium for exchange of facts, experience and thought; and to represent, advance, and protect the standards of the science of soil and water conservation.*"

This broad statement of objectives certainly implies that there is more than research and technical assistance involved. To "*promote all phases*" to me means not only to get the answer but to put it on the land. It also means good land use and the development of the arts of application, understanding and working with people. A farmer who developed and is carrying out a conservation program on his farm is a true conservationist, a conservation farmer, just as is the technician who helped him with the planning and application, and the research man who tested the methods. A recent study made by the Research Administration in the Department of Agriculture revealed that while the research ceilings on production per acre and per animal have leveled off during recent years, there is still a substantial gap of approximately 50 per cent between the level of per unit production possible through full application of science and the level of per unit production on the farms of the nation. The study indicates that we are reaching the stage with most farm commodities where opposing forces—insects, diseases, soil deterioration, etc., are pushing down on yields as hard as research is pushing up on them.

Between the technician and the farmer are the numerous groups who must support the movement if, in the long run, it is to succeed. Representatives of the various industries who manufacture products for the farmer as well as those whose vision shows them the importance of soil conservation to the general welfare of all the people, can use this "medium for exchange of facts, experience, and thought."

And so we have the place in the Society for the research man, the technician, professional men in closely allied fields to soil conservation, and the teacher in the field of conservation. We have the farm operator who uses the facts from research and the services of the technician to put the facts to work. And we have the vast middle group whose welfare depends on how well the other two groups do their job.

R. H. Musser, a charter member of the SCSA, is regional director for The Soil Conservation Service. His headquarters are in Milwaukee, Wisconsin. Mr. Musser is a past-president of the SCSA.

There need be no fear of overlapping between the Soil Conservation Society of America and other societies or organizations whose major objectives are different although they are in the conservation field or closely allied fields. Members of the National Association of Soil Conservation Districts, men administering an action program in soil conservation districts, will find the Society an opportunity for making and maintaining contacts with professional conservationists. And they can do the Society much good by their experience on the "*ground*" and in pointing the way for widespread application of sound conservation based on research and experience.

Society Provides Common Meeting Ground

There are many specialists-engineers, agronomists, soil scientists, and others working in the conservation field but who also belong to professional societies of their own. These people belong in the Soil Conservation Society as well as their special organization. By so doing, they strengthen both organizations.

I believe in a more liberal policy on membership. As long as any man pledges himself to active participation in the development and advancement of the science of soil and water conservation and works at it, he is, in my opinion, deserving of membership.

The professional as well as the non-professional conservationist can find a common meeting ground in the attainment of a common set of objectives.

In my opinion, membership should come from the following fields:

1. Every man who is making soil and water conservation work a career.

2. Any man who is teaching soil and water conservation, carrying on research in the field of soil and water conservation; or engaged in the field of administration of soil and water conservation activities and programs, i.e. (college staff, vo-ag teachers, soil conservation district supervisors, county agents, agricultural professional men in industry, etc.).

3. Any man who is scientifically practicing soil and water conservation. This would include conservation farmers, of course.

4. Others who will work for the realization of the Society's objectives and will commit themselves to support and abide by the constitution and by-laws of the Society.

Many of these people would and should also belong to other educational conservation organizations such as Friends of the Land. This organization has made a tremendous contribution to the conservation movement by enlisting understanding and the support of large urban groups.

If we keep our objectives clear and participate constructively and actively in the attainment of these objectives, then the matter of membership classification will be of minor importance. The accomplishment of the Society will be great and of major importance to the welfare of the citizens of America and our way of life.

All members should pay an equal required membership fee. College students preparing for a professional career in soil conservation could well be given a complimentary membership. They are professional men in the making. Libraries should pay a subscription fee as they are now doing.

Any member should be privileged to contribute any amount above the required membership fee for general use of the Society or for a special purpose stated by him and agreed to by the Council.

There are no less than 20,000 people who can qualify as active members if we, as members, are really interested in the advancement of sound soil and water conservation and the development and advancement of its science.

EDITOR'S NOTE: Because of the importance of the thought-provoking ideas contained in this article, JOURNAL readers are urged to express their views in writing to Ralph H. Musser, 434 N. Plankinton Avenue, Milwaukee 3, Wisconsin.

"The well being of our nation is dependent upon the continued productivity of the land, since the products which fulfill man's basic needs originate from the soil. Livestock farming is the natural way to maintain soil fertility. Grasses and legumes, which are an essential part of soil conservation, are practical and profitable only because they can be marketed through livestock."

—Thos. E. Wilson,
Chairman of the Board,
Wilson & Co., Inc.

Consumptive Use of Water and Irrigation Requirements

WAYNE D. CRIDDLE

Consumptive use (or evapo-transpiration) includes loss of water by evaporation from the surface of the soil and loss from interception by vegetative cover and plant transpiration. This paper discusses the factors affecting consumptive use, research studies of the problem and methods of measuring and estimating consumptive use of agricultural crops. Nomographs have been developed for quickly determining monthly consumptive-use rates, peak daily-use rates and required flow rates for use in designing irrigation systems.

WATER IS THE LIMITING factor in the expansion of irrigated agriculture. Thus, in irrigation planning, it is essential that consumptive use and irrigation water requirements be known. This is true for large irrigation projects or for individual farms and whether in the arid west or in the more humid east.

Consumptive use, evapo-transpiration, is one of the important elements in the cycle of water movement from the time it falls on the land as rain or snow until it reaches the ocean. It is the best index of how much water will need to be supplied by irrigation for good production.

The determination of consumptive use and irrigation water requirements involves consideration of water supply, both surface and underground, as well as those of the management and general economics of irrigation projects. A knowledge of water requirements has become an important factor in the arbitration of controversies over major stream systems of the west where the public welfare of valleys, cities, states, and even nations is involved.

New irrigation development is rapidly taking place throughout the United States. New lands are being brought under irrigation. Older irrigation lands are being re-leveled and irrigation systems are being revised to accommodate improved irrigation practices for better conserving soil, water and labor. There is urgent need for sound information on the amount of irrigation water required for profitable crop production.

Before equitable division of the use of water available in a drainage basin in arid and semi-arid regions can be satisfactorily ascertained, careful consideration must be given to the consumptive-use requirements for water in various sub-basins.

In water supply and irrigation investigations, engineers are frequently called upon to make, within a limited time, estimates of probable past, present, and future evaporation and transpiration losses from river valleys. Frequently few long-period hydrologic records, except climatological data, are available. The results of research of evapo-transpiration provide the practicing engineer with basic data and suitable methods for estimating consumptive use in water utilization investigations.

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Definition of Consumptive Use

In some instances there has been confusion as to the meaning of terms employed in reports on the use of water. Such terms as "consumptive use," "evapo-transpiration," "total evaporation," "streamflow depletion," "water requirements," "irrigation requirements," and "duty of water" have been used interchangeably.

In this paper, only the terms "consumptive use" and "evapo-transpiration" are considered synonymous. They may be defined as "the sum of the volumes of water used by the vegetative growth of a given area in transpiration and building of plant tissue and that evaporated from the adjacent soil, snow or intercepted precipitation on the area in any specified time divided by the given area." If the unit of time is small, the consumptive use is expressed in acre-inches per acre or depth in inches; whereas, if the unit of time is large, such as a crop-growing season or a twelve-month period, the consumptive use is usually expressed as acre-feet per acre or depth in feet.

Figure 1.—Evaporation-transpiration station. Two tanks at the right still have wheat growing. Alfalfa tanks in the center have been harvested. A standard Weather Bureau type evaporation pan, anemometer and rain gage are shown in the foreground.

Figure 2.—Alfalfa growing in a double-walled tank surrounded by alfalfa. Consumptive use of water by alfalfa is relatively high in comparison with most other agricultural crops.

Factors Affecting Consumptive Use

Many factors operate singly or in combination to influence the amount of water consumed by plants. The effects of these factors are not necessarily constant, but they fluctuate from year to year as well as from place to place. Some involve the human factor but others are related to natural influences and the environment.

The rate of evapo-transpiration depends on climate, soil moisture supply, vegetative cover, soils, and land management. The climatic factors that particularly affect consumptive use are precipitation, temperature, humidity, wind movement, and length of growing season. Also, the quantity of water transpired by plants depends upon the amount of water at their disposal. Certainly if there is no water available to the plants, there can be no transpiration, and if the plants are under heavy water stresses, water use will be small. Other factors affecting the use of water are the state of the development of the plant, the amount of its foliage, and the nature of its leaf.

The effect of sunshine and heat on stimulating transpiration was studied as early as 1691 according to a review of the literature by Cleveland Abbe (1). Measurements of transpiration by various kinds of plants by L. J. Briggs, and S. H. Shantz (2) (3) indicate a closer correlation between transpiration and evaporation from free water surfaces, air temperature, solar radiation, and wet bulb depression readings. Various scientists have made many other studies of the effects of temperature, moisture, and light on plant growth.

Studies and Results

Research studies by federal, state and other agencies have been made on evaporation and transpiration at various times during the past 50 years in the United States. One of the first studies (4) of evapo-transpiration losses of irrigated crops in California was made in 1903 by Irrigation Investigations, Office of Experiment Stations, United States Department of Agriculture.

At various times since that date, this agency, which is now part of the Soil Conservation Service, has studied and measured consumptive use of water by different agricultural crops and natural vegetation in many sections of the west in cooperation with state engineers, state agricultural experiment stations, and other agencies. In fact, during the past five years, state reports have been published for 12 of 17 western states. These reports, many of which are published as state agricultural experiment station bulletins, give estimated rates of consumptive use of water by each of the more important crops in each irrigated area of the state. Many consumptive-use investigations are under way.

Usually, evaporation, temperature, humidity, precipitation and wind movement were recorded at the same time. Thus, data are available in many areas for correlating consumptive-use measurements with temperature and other climatological observations.

The results of studies in California, Colorado, and New Mexico indicate that the observed evaporation data may be used as a means of estimating evapo-transpiration by phreatophytes (water-loving vegetation) having access to an ample water supply when the relation of the two is known for the particular area (5) (6). As an example, for tules growing in large tanks within the confines of a swamp area at two locations in California, the consumptive use with reference to evaporation from the nearby exposed United States Weather Bureau pan was 95 per cent. The percentage varied from month to month, increasing in the summer and becoming smaller in the cooler months, but 95 per cent was the average obtained for a two-year record.

From long-period records of evaporation, temperature and humidity in New Mexico and Texas, together with consumptive use measurements at Carlsbad, New Mexico, empirical formulas were developed for computing evaporation and consumptive use when temperature and humidity data are available (6).

Methods of Determining Water Use

Scientists have tried various means to determine the amount of water transpired by plants (7). One of the earliest methods consisted of weighing freshly cut leaves,

twigs, or stocks of growing plants immediately after cutting and at short intervals thereafter until wilting commenced. Thousands of individual plants have been grown in small pots and weighed periodically to determine evapo-transpiration losses. Most of these methods utilize artificial conditions, and it is questionable whether the results can be extended to field conditions.

Various methods have been used by engineers to determine consumptive use of water by agricultural crops and natural vegetation under field conditions (8). Regardless of the method, the problems encountered are numerous. The source of water used by plant life, whether from precipitation alone or irrigation or ground water plus precipitation, is a factor in selecting a method.

The methods most widely used in irrigation investigations are (a) soil-moisture studies on fields and plots, (b) tank or lysimeter experiments, (c) ground-water fluctuations, (d) inflow-outflow measurements, (e) integration, (f) effective heat, (g) correlation of water use, climatological data and other data, and (h) analysis of irrigation and precipitation records.

Soil moisture studies: This method is employed to determine the consumptive use of irrigated fields on which the soil is fairly uniform and the depth to ground water is such that it will not influence the soil moisture fluctuations within the root zone. Soil samples are taken before and after each irrigation and at frequent intervals between irrigations. Usually a great number of soil samples must be taken. The total depth of water extracted from the soil by evapo-transpiration is computed for each period between samplings.

Tank and lysimeter experiments: One of the more common methods of determining use of water by individual agricultural crops and natural vegetation is to grow the plants in tanks or lysimeters and measure the quantity of water necessary to maintain satisfactory growth. Tanks as large as ten feet in diameter and ten feet deep have been used. However, in most consumptive-use studies, the tanks are about two to three feet in diameter and six feet deep.

The practicability of determining consumptive use by means of tanks or lysimeters is dependent upon the accuracy of reproduction of natural conditions. In addition to environment, artificial conditions are the result of limitations of soil, size of tank, or regulation of water supply. Weighing is the precise means of determining the consumptive use from tanks and this method was used as early as 1907. However, conditions and facilities will not always permit the weighing of tanks. It has been found that all tank vegetation must be protected from the elements by a surrounding growth of the same species.

Ground-water fluctuations: Where ground water is relatively near the land surface, evapo-transpiration losses are indicated from large areas by the daily rise and fall of the water table. Diurnal measurements of the ground-water table fluctuations provide a basis for computing consumptive use of water by overlying vegetation. This method has been used successfully by the Geological Survey, U. S. Department of the Interior, in various areas of Utah, California and Arizona (9).

Figure 3.—The use of water by native vegetation is also measured in evapo-transpiration tanks. This picture shows cattails growing to a height of about two feet. Cattails are one of the heaviest users of water.

The procedure used is to install observation wells equipped with water stage recorders at representative locations in the area under consideration and to obtain graphic record of the ground-water fluctuations. The specific yield of the soil is determined by standard methods. Diurnal cycle as indicated by the ground-water table represents a curve showing the relation of consumptive use to ground-water discharge or recharge.

Inflow-outflow measurements: Consumptive use of water by cottonwoods, willows, tules, and other riparian vegetation common to small streams may often be most easily determined by measuring the inflow to and the outflow from a selected area including precipitation and change in ground-water storage. In the investigations conducted in the Upper Rio Grande (5) Pecos River (6) and other river valleys, engineers have used the inflow-outflow method to determine the total consumptive use of water in irrigated valleys containing land areas up to 400,000 acres.

Integration method: Briefly stated, the integration method considers consumptive use in a valley to be the summation of the products of the use of water by each crop times its area, plus the use of water by the natural vegetation times its area, plus water surface evaporation times water surface area, plus evaporation from bare land times its area.

This method was used in the Upper Rio Grande Basin (5) and the Pecos River (6) investigation to determine valley consumptive use. Before the integration method can be used successfully, it is necessary to know unit rates of use of water by the various agricultural crops and natural vegetation, and unit rates of evaporation from bare land and water surfaces.

Effective heat: For many years, irrigation engineers have used temperature data in estimating valley consumptive use of water in areas of the west (10). Hedke developed the effective heat method on the basis of studies of the Rio Grande. By this method, consumptive use is estimated from a study of the heat units available to the crops of a particular valley. It assumes that a linear relation exists between the amount of water consumed and the quantity of available heat. Studies by the Bureau of Reclamation, United States Department of the Interior, developed a somewhat similar method which has been used quite generally in making its estimates of consumptive use.

In 1940, in connection with the Pecos River Joint Investigation (6), a method of estimating consumptive use by natural ground-water vegetation and by irrigated crops having access to an ample water supply was developed. Correlation of the relationship between transpiration, evaporation, temperature, daytime hours, length of growing season, and humidty was used in the estimate (11). In 1945, this method was modified to make possible estimates of consumptive use for areas in which humidity records are not available. This method (12) has been used by the Soil Conservation Service and other agencies in estimating rates of water consumption in many areas.

Correlation of Water Use With Climatological and Other Data

Actual measurements of consumptive use under each of the physical and climatical conditions of any large area are expensive and time consuming. Therefore, some rapid method of transferring the results of measurements, made in several areas, to other areas is needed. Such a method was developed by the Soil Conservation Service (12). Briefly, the procedure is to correlate existing consumptive-use data with monthly temperatures, percentage of daytime hours, precipitation and frost-free (growing) period, or irrigation season. The coefficients so developed for different crops are used to translocate or transpose consumptive use- data from one location to others in which climatological data alone are available.

Although it is recognized that use of water is affected by numerous factors, records of temperature and precipitation are by far the most universally available data throughout the western states. Studies indicate that, of all the climatic factors, these elements, together with day light, undoubtedly have the greatest influence on plant growth. Thus it is assumed that consumptive use varies directly with the mean monthly temperature (t) multiplied by the monthly percentage of daytime hours of the year (p). Expressed mathematically

$$u = KF = \Sigma kf$$

in which u is the consumptive use of water by the crop in inches for any period; F is the sum of the monthly consumptive-use factors (f) for the period; K is the empirical consumptive-use coefficient.

The consumptive-use factor (F) for any period may be computed for areas in which monthly temperature records are available and consumptive-use coefficients (K) for the more important irrigated crops (ground under normal conditions in the west) are shown in Table 1. These coefficients were developed from actual measurements of consumptive use by the various methods.

Monthly percentage of annual daytime hours computed from sunshine tables (13) are shown in Table 2.

Table 2.—Normal Consumptive-Use Coefficients For The More Important Irrigated Crops and Natural Vegetation Of The West

Item	Length of growing season or period	Consumptive-use coefficient (K)
Alfalfa	frost-free	0.85
Beans	3 months	.65
Corn	4 months	.75
Cotton	7 months	.62
Citrus orchard	7 months	.55
Deciduous orchard	frost-free	.65
Pasture, grass, hay, annuals	frost-free	.75
Potatoes	3 months	.70
Rice	3 to 4 months	1.00
Small grains	3 months	.75
Sorghum	5 months	.70
Sugar beets	5½ months	.70

A nomograph, Figure 4, has been developed for the solution of the consumptive-use formula, u=kf. If the mean monthly temperature and the latitude of the area are known, it is possible to determine the normal monthly consumptive use of any crop for which k is known.

As an example, assume that it is desired to know what the July consumptive use of water by sugar beets

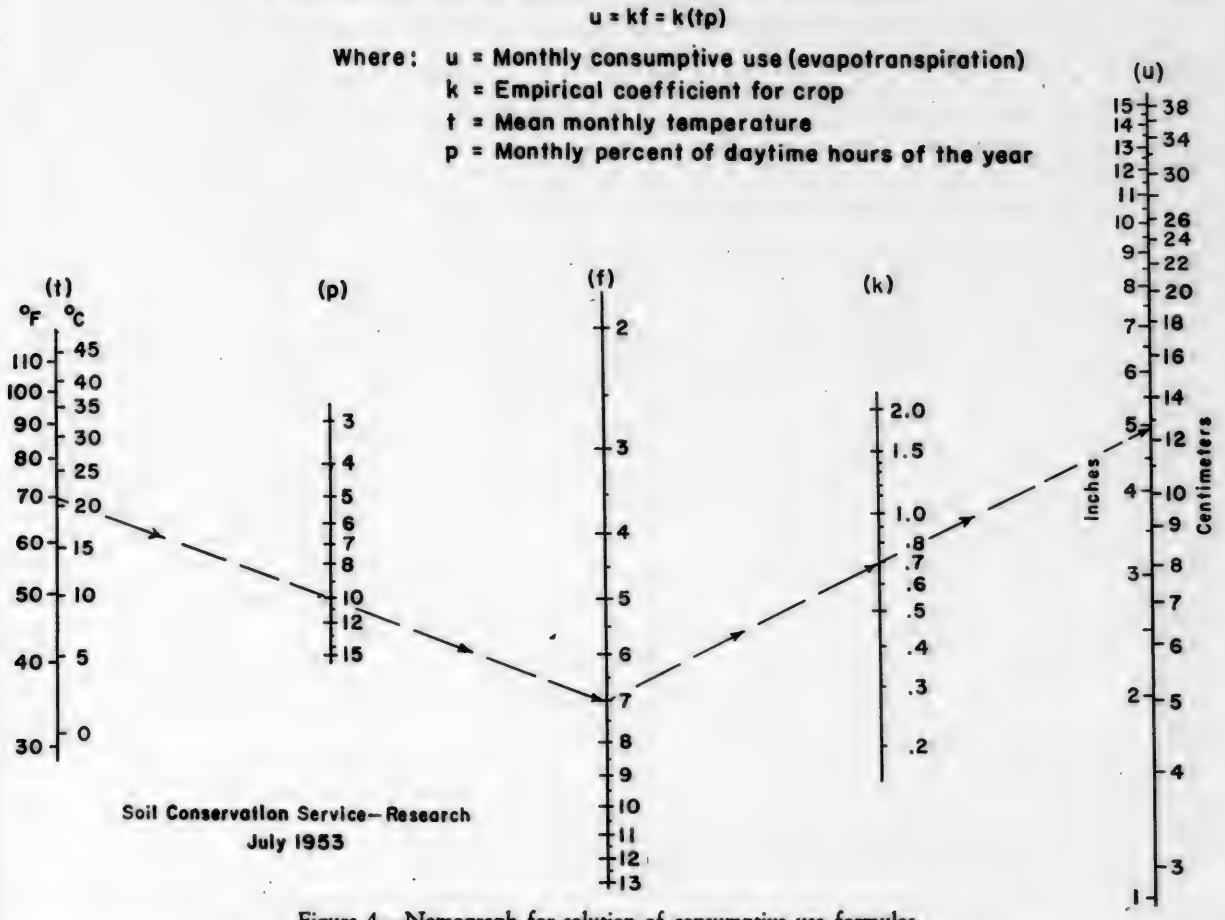

Figure 4.—Nomograph for solution of consumptive use formulas.

might be in an area of latitude 36°, whose mean temperature during the month was 70°F.

From Table 1, the consumptive-use coefficient for sugar beets is 0.70. From Table 2, "p" is 9.99 percent. Entering the nomograph with the above values of "t" and "p," we find that "f"=7.0. With a "k" of 0.7, the use of water by sugar beets during July will be about 4.9 inches. Had the crop been alfalfa with a "k" of 0.85, the normal July use would be about six inches. In other words, six inches of water must be made available for crop use during the month. This requirement may be met from precipitation, carry-over soil moisture

Table 2.—Monthly Percentage of Daytime Hours of the Year for Latitudes 24° to 50° North of the Equator

Month	Latitudes in Degrees North of Equator													
	24	26	28	30	32	34	36	38	40	42	44	46	48	50
January	7.58	7.49	7.40	7.30	7.20	7.10	6.99	6.87	6.76	6.62	6.49	6.33	6.17	5.98
February	7.17	7.12	7.07	7.03	6.97	6.91	6.86	6.79	6.73	6.65	6.58	6.50	6.42	6.32
March	8.40	8.40	8.39	8.38	8.37	8.36	8.35	8.34	8.33	8.31	8.30	8.29	8.27	8.25
April	8.60	8.64	8.68	8.72	8.75	8.80	8.85	8.90	8.95	9.00	9.05	9.12	9.18	9.25
May	9.30	9.38	9.46	9.53	9.63	9.72	9.81	9.92	10.02	10.14	10.26	10.39	10.53	10.69
June	9.20	9.30	9.38	9.49	9.60	9.70	9.83	9.95	10.08	10.21	10.38	10.54	10.71	10.93
July	9.41	9.49	9.58	9.67	9.77	9.88	9.99	10.10	10.22	10.35	10.49	10.64	10.80	10.99
August	9.05	9.10	9.16	9.22	9.28	9.33	9.40	9.47	9.54	9.62	9.70	9.79	9.89	10.00
September	8.31	8.31	8.32	8.34	8.34	8.36	8.36	8.38	8.38	8.40	8.41	8.42	8.44	8.44
October	8.09	8.06	8.02	7.99	7.93	7.90	7.85	7.80	7.75	7.70	7.63	7.58	7.51	7.43
November	7.43	7.36	7.27	7.19	7.11	7.02	6.92	6.82	6.72	6.62	6.49	6.36	6.22	6.07
December	7.46	7.35	7.27	7.14	7.05	6.92	6.79	6.66	6.52	6.38	6.22	6.04	5.86	5.65
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

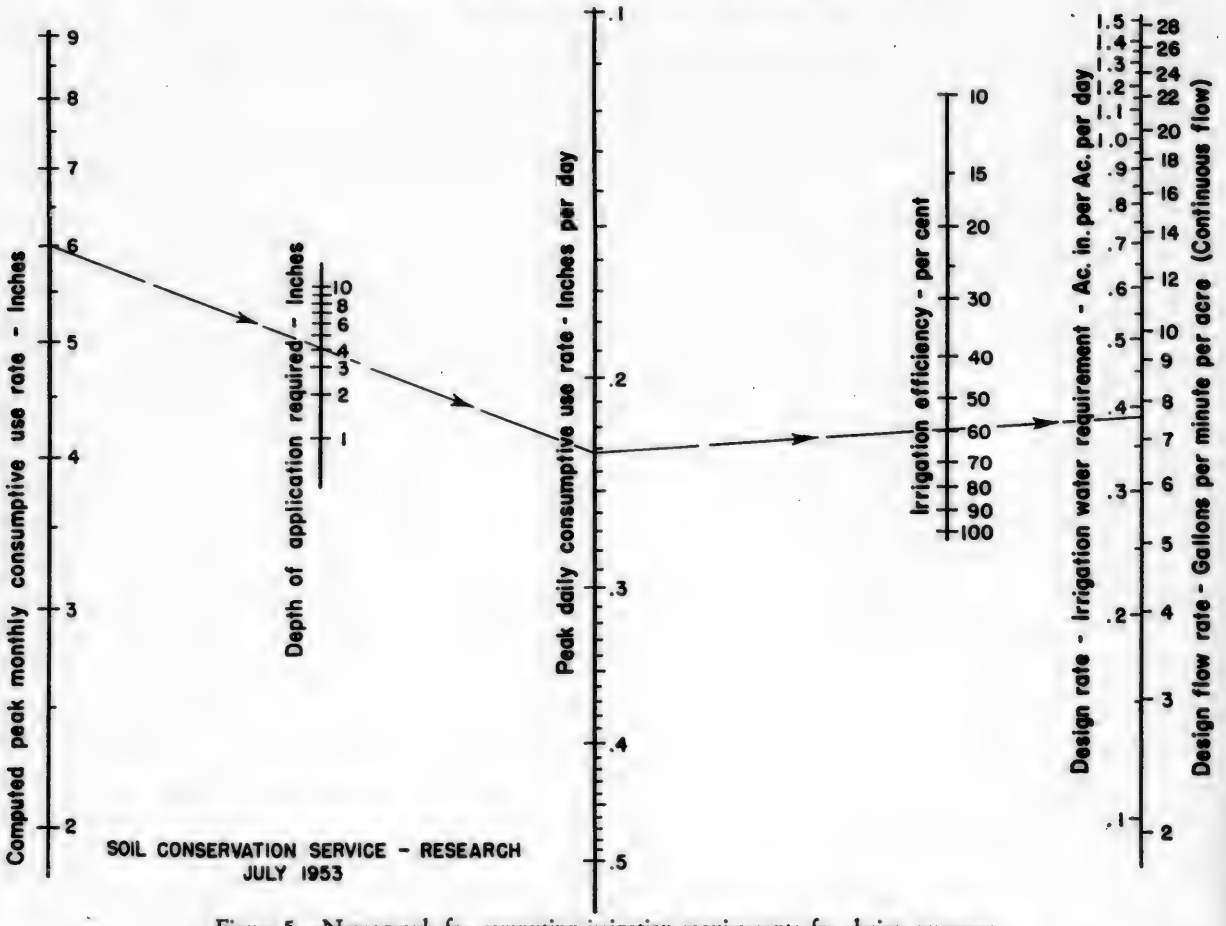
Computed peak monthly consumptive use rate - Inches
Depth of application required - Inches
Peak daily consumptive use rate - Inches per day
Irrigation efficiency - per cent
Design rate - Irrigation water requirement - Ac. in. per Ac. per day
Design flow rate - Gallons per minute per acre (Continuous flow)
SOIL CONSERVATION SERVICE - RESEARCH
JULY 1953

Figure 5.—Nomograph for computing irrigation requirements for design purposes.

from the previous month, ground water and/or irrigation. In the hot, dry, western areas, most, if not all, of this requirement must be met by irrigation. As we move eastward, more and more of the crop needs may be met by summer precipitation.

Peak Use for Design Purposes

In the design of farm irrigation systems, particularly the more expensive systems, the peak consumptive-use rate is of major importance. Likewise, the peak rate at which water is used by the crops influences the administration of the streams and reservoirs supplying the water and determines the carrying capacities needed for the entire irrigation system.

One of the greatest faults of many existing sprinkler system is their inability to meet the peak use requirements of the crops. Allowing excess moisture stress to develop in the plants just once during the growing season may sharply curtail yields or materially lower the quality of the produce.

The frequency of irrigation is dependent upon the length of time the water stored in the crop root zone will last under plant use. Since consumptive use is not constant over any extended period of time, daily peak use may be considerably greater than the average daily rate for a month. Therefore, the less water that can be stored in the root zone of the crop at any one time, the greater the capacity of the irrigation system must be if the crop needs are to be met fully during the short periods of high use rates.

Based on studies conducted at various locations throughout the west, the nomograph, Figure 5, was prepared to assist in estimating peak rates of water consumption for irrigation system design purposes.

To use Figure 5, it is first necessary to know the peak monthly consumptive-use rate and the depth of water that is to be stored each irrigation. From this can be obtained the peak daily consumptive-use rate. Irrigation water cannot be applied at 100 per cent efficiency. However, if the irrigation efficiency is known, the design rate in acre inches per acre per day or the flow rate in gallons per minute per acre can be determined. Example:

(*Continued on page* 245)

Watershed Management Experiments in the Colorado Front Range

L. D. LOVE

Summer cloudburst storms occur frequently on the eastern flank of the Colorado Range below 9,000 feet elevation. The intensity of these storms is high, often exceeding three inches per hour for 10-minute intervals. Floods from the cloudburst storms cause much damage to lands and improvements in the adjacent plains. A considerable portion of this damage is due to sediment deposited in stream channels and reservoirs, across mountain roads, in homes and towns, in irrigation canals and ditches.

Sediment damage amounts to over $600,000 annually in the South Platte River system above Greeley, Colorado (8). A principal contributor of sediment is the forest and range foothill area where sheet and gully erosion account for 95 per cent of the sediment deposited and the annual rate amounts to 0.25 acre-foot per square mile (Figure 1).

PLOT STUDIES in the Colorado Front Range show that heavy grazing by livestock doubles the amount of surface erosion and increases runoff by about two-thirds when compared to plots moderately grazed. Infiltration studies point to a decrease of 118 per cent in the water absorption rate of mixed granitic and schist soils when very poor forage condition is contrasted to good. These and other studies illustrate the extent to which native vegetation can lessen accelerated erosion and runoff. This decrease can do much toward reducing sediment damages in the Colorado Front Range and adjacent plains.

The Colorado Front Range extends from Canon City, Colorado, into Wyoming, where it merges with the Laramie Range without a perceptible topographic break. The eastern border of the Front Range follows a slightly curved north-south line, passing a short distance west of Colorado Springs, Denver, and Fort Collins. Its topography stands in sharp contrast to the plains to the east. Westward, the Front Range reaches to the crest of the Continental Divide (3).

The low-elevation (6,000-9,000 feet) forests and grasslands of the Colorado Front Range are the mountain sediment-source areas of the South Platte River drainage. The lands are rough and broken, and are dissected by many tributary drainageways. A considerable portion contains soils derived from Pikes Peak granite, reddish in color, and highly susceptible to the forces of erosion. A smaller portion is made up of soils developed from limestones and sandstones, but equally susceptible to erosion because of its steep, hogback topography.

On the Manitou Experimental Forest in Colorado, watershed-management experiments have now been underway about 18 years. This forest, lying just west of the Rampart Range, is eight miles north of Woodland Park, Colorado, and is in the South Platte River drainage. It is located within the foothill zone (6,000-9,000 feet elevation) from which considerable sediment is deposited in mountain streams. The annual water yield appearing as streamflow varies between two and five inches—less than 20 per cent of the annual precipitation. Open forests of ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga taxifolia*), and aspen (*Populus tremuloides*), with an understory of Arizona fescue (*Festuca arizonica*), mountain muhly (*Muhlenbergia montana*), and a variety of shrubs are characteristic of the Experimental Forest and the foothill zone within which it lies (Figure 2), In isolated areas virgin forest predominates, but stands of second growth are the rule.

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Watershed-Management Experiments

Most of the precipitation in the foothill zone occurs as rain during the spring and summer months. Frequently the rainfall comes in the form of cloudburst storms of high intensity but of short duration. Watershed-management experiments have dealt primarily with studies of the infiltration of water, surface runoff, and erosion of the soils developed from granitic and other geologic materials. The purpose has been to determine what factors in the ponderosa pine—bunchgrass ranges will provide the optimum conditions for water absorption and for the reduction of surface runoff and erosion from cloudburst storms.

Surface runoff and erosion from six 1/100-acre plots have been measured at the Manitou Experimental Forest for 15 years (2). The plots are distributed in two batteries of three each, lying on a 17 per cent north-facing slope. Each plot is enclosed by sheet-metal baffles and at the foot of each, a series of tanks is used to collect runoff water and eroded material.

Vegetation on the plots is primarily grasses—Arizona fescue and mountain muhly—a combination typical of

Figure 1.—Sediment bars in the South Platte River channel move downstream at the rate of about 1½ miles per year and are erosion depositions from steep slopes, gullies, and roads. (*Pike National Forest*).

most ponderosa pine-bunchgrass ranges. The relatively permeable soil originates from a gravelly alluvium, an outwash of Pikes Peak granite.

From 1938 to 1941 the plots were not grazed so that erosion and runoff from undisturbed sites could be assessed. Following this "calibration period" a cattle-grazing treatment was applied. Two plots were heavily grazed by removing 66 per cent of the herbage, and two moderately by removing 33 per cent of the herbage. The remaining two were retained as undisturbed checks. Grazing was regulated by an adjustable electric fence and intensities judged by stubble heights.

The effect of grazing is most pronounced during the summer rainfall period—June to September, inclusive. Runoff during these months in the pretreatment period was substantially the same for all plots, indicating uniformity before disturbance. Subsequent grazing resulted in a jump from 0.14 area-inch of runoff from the check plots to 0.44 area-inch from the heavily grazed plots. Moderate grazing resulted in an average yield of 0.28 area-inch per season.

Erosion occurred almost exclusively during the months of July and August, a period of high-intensity rainstorms. During calibration the average amount of erosion during the summer period varied from 72 to 98 pounds per acre. After grazing was started no significant change occurred as a result of moderate use, but heavy use virtually doubled the normal amount—an increase to 171 pounds per acre.

Not all rainstorms cause soil erosion from the runoff plots. The average cloudburst storm causing erosion amounts to 0.96 inch of precipitation and a storm of this size is expected to occur once or twice during the summer season.

Heavily grazed plots are poorly protected against the beating action of these intense storms. More soil is dislodged and started downslope because the vegetation is not there to break the force of raindrops and the hail that is often mixed with the rain. Less water can enter the soil because absorption capacity has been lowered by trampling, reduced litter, and the sealing action of the raindrops. The result is that erosion on heavily grazed plots is more than twice the amount of that on moderately grazed and control plots (Figure 3).

The ponderosa pine—bunchgrass ranges are found on a variety of slopes and exposures in the foothill zone. Cloudburst storms capable of causing erosion and runoff occur at such unpredictable intervals that it is difficult to study their effects under the different conditions found in the pine-bunchgrass ranges. As a consequence, many of the watershed-management experiments at the Manitou Experimental Forest and elsewhere in the foothill zone have included the application of rainfall in controlled amounts to small plots which are

enclosed by metal frames. These frames, 2.5 square feet in size, can be installed quickly and moved about to study a variety of conditions. Both the rainfall applied, and the amount of surface runoff and erosion occurring, are measured at definite intervals. The difference between the rain applied and the measured runoff provides the infiltration or water-absorption rate of the soil. The amount of erosion measured gives the relative erodibility of the soil surface under different conditions of vegetation cover, slope, and exposure (1).

Initial plot studies of this nature compared surface runoff and erosion under two rainfall intensities on three plant-cover types on two soils (4). Rainfall was applied to plots enclosed by a metal frame 1/200 acre in size for a 30-minute period. Both water applied and runoff were measured at 3-minute intervals; soil material eroded during the 30-minute period was collected, air-dried, and weighed to determine the amount of erosion on each plot. Table 1 summarizes the results of these studies.

Table 1.—Comparison of surface runoff and erosion on three plant-cover types

Cover and soil type	Rain intensity	Surface runoff	Erosion per cubic foot of runoff
	in./hr.	*cu. ft.*	*Grams*
Abandoned field on alluvial soil	2	7.8	233.3
	4	24.1	172.6
Bunchgrass on alluvial soil	2	6.5	64.8
	4	19.4	66.7
Bunchgrass on residual soil	2	2.0	111.3
	4	8.2	105.3

Runoff was greatest on the abandoned field, intermediate on the bunchgrass on alluvial soil, and least on the bunchgrass on residual soil. An increase in rainfall intensity from two to four inches per hour more than tripled the surface runoff for all types. The differences between the cover types were real and were not ascribed to chance.

Erosion was most rapid on the abandoned field, intermediate on the bunchgrass on residual soil, and least on the bunchgrass on alluvial soil. The total volume of eroded material increased with increased rainfall intensity, but the amount of material carried per cubic foot of runoff showed no significant change. The differences between the cover types were not due to chance variations of cover and soil.

It was concluded from these studies that where a good plant cover prevailed on the coarse, porous soils, surface runoff and erosion would be greatly lessened. With this information as a background, more extensive studies were undertaken to determine the relative infiltration and erosion rates of different vegetation types growing on soils derived from a variety of geological materials.

Figure 2.—Rough, broken lands of the foothill zone are the flood and sediment-source areas of the Colorado Front Range. (*South Boulder Creek*)

Infiltration, or water-absorption and erosion studies, follow the procedures described in a bulletin by Dortignac (1) and by Wilm (9) (Figure 4). The water-absorption rates, expressed in inches per hour, are the average rates for the last 20 minutes of a 50-minute infiltration run. Generally, plots are prewetted and the soils allowed to drain for 12 to 24 hours before the run is made. Erosion rates are determined by collecting the total amount of soil materials moving off the plots, oven-drying this amount, and expressing the result in pounds per acre per inch of surface runoff.

It is quite common in the foothill portion of the Colorado Front Range for water to run off the land surface in a flashy type of flow, bringing with it heavy loads of sediment and leaving depleted eroded sites. Two factors cause this. One is the high intensities often reached in rainstorms and the other is the inadequacy of vegetative cover. Man's use of the land, of course, greatly modifies and often deteriorates the protective influence of the vegetation. Aside from these modifications, wide variations exist in natural protective qualities. This has been borne out by infiltration and erosion studies made on three vegetation types growing on soils derived from granite.

A summary of the results of this study follows:

Vegetation type	Range in slope	Average infiltration rate	Average erosion rate[1]
	Percent	*Inches/hour*	
Aspen	9-41	4.30	16
Ponderosa pine	9-39	3.14	557
Mountain brush	24-56	3.22	2,356

[1]Expressed as pounds per acre per inch of surface runoff.

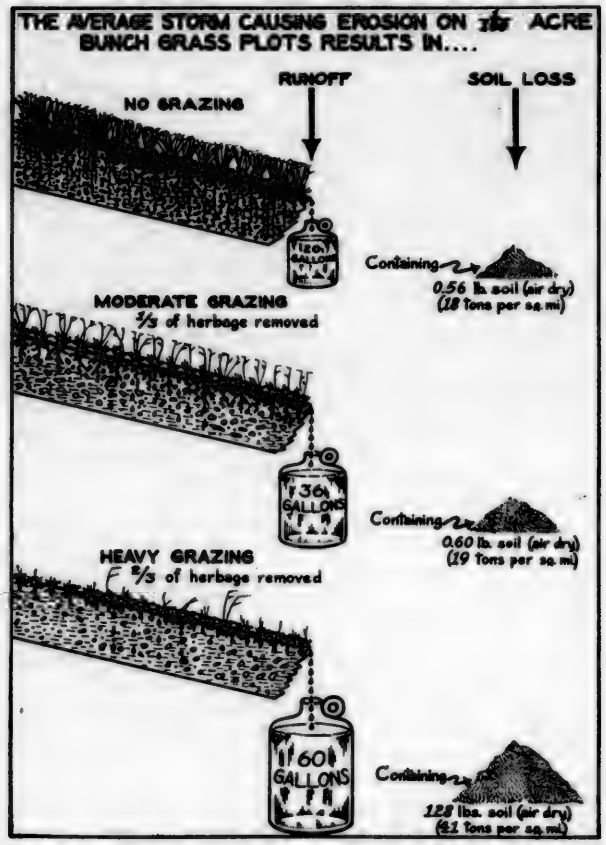

Figure 3—Intense rainstorms cause more soil loss and runoff on heavily grazed plots. (*Manitou Experimental Forest*)

The aspen type, by virtue of its high infiltration rate and low erosion rate, provides superior watershed protection. The ponderosa pine type, although having a moderately high infiltration rate, has also an accelerated erosion rate which is not as serious as that found on the mountain-brush type. Infiltration rates of the mountain-brush type are moderately high, but the runoff which does occur moves large quantities of soil. Unlike the other two types, the ground surface is not well protected by plants or litter, often consisting only of a bare gravel pavement from one to two inches thick. It is capable of absorbing water rapidly due to its gravelly nature, but is highly erodible even when small surface flows of water occur. These studies show that, among the three types studied, mountain brush provides the poorest watershed protection, ponderosa pine is intermediate, and aspen is the best.

A similar study was carried out in three intermixed vegetation types on soils developed from granitic alluvial materials. These soils differ from those of the previous study in that they are of finer texture and exhibit definite profile characteristics (7). The infiltration plots were not prewetted before the infiltration runs were made, rather a complete "dry" run was conducted first, followed by a "wet" run on the same plot 15 to 24 hours later. The dry run deals with conditions similar to those encountered when a rainstorm occurs on a dry soil, while a wet run deals with conditions found in a wet soil. Such studies are of significance since it has been observed that the greatest amount of surface runoff occurs from rainstorms which follow each other by a period of 24 to 36 hours (8). In this case the water-storage capacity of the soil has been reduced by the amount of water absorbed during the first storm, thus limiting the amount that can be absorbed from the ones that follow.

The results of this study are summarized below:

Vegetation type	Average slope	Average infiltration rate		Average erosion rate[1]	
		Dry Run	Wet Run	Dry Run	Wet Run
	Percent			*in./hr.*	
Ponderosa pine—litter	16	2.22	2.07	209	161
Ponderosa pine—grass	9	2.13	1.96	160	139
Grassland	8	2.00	1.59	249	222

[1]Expressed as pounds per acre per inch of surface runoff.

The infiltration rates are greater during the dry runs

Figure 4.—Rocky Mountain infiltrometer used to apply rain to small plots to obtain rates of water absorption, runoff, and erosion under different conditions of vegetation, soil, and use. (*Manitou Experimental Forest*)

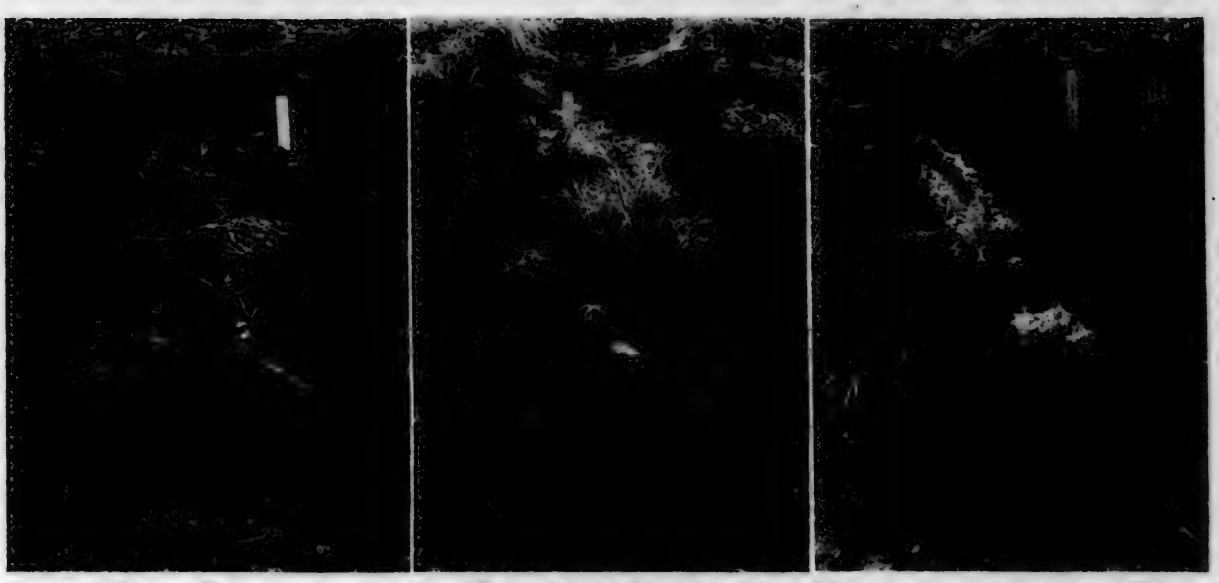

Figure 5.—These infiltrometer plots show that different "plant-soil complexes" have different surface erosion and runoff characteristics as exhibited by the protection they provide the soil surface. (*Manitou Experimental Forest*). Left to right Ponderosa pine—litter on granitic alluvial soils, Ponderosa pine—grass on granitic alluvial soils, and Grassland on granitic alluvial soils.

than during the wet runs, indicating a greater capacity of the soils to absorb water under dry conditions. The greatest difference occurs in the grassland which does not have a heavy pine needle litter cover to facilitate the absorption of water.

The difference between the erosion rates for the dry and wet runs does not necessarily mean that more erosion occurs during dry soil conditions. True, the rate is higher but the amount of runoff is less because of the higher infiltration rates. More total surface erosion will occur under wet soil conditions than under dry, since there is more surface runoff to move the soil materials. The higher erosion rate observed during the dry runs appears to be due to the looseness of the surface soil particles and to their initial resistance to wetting. Once wetted, the surface soil particles appear more firmly fixed and are less subject to transportation by water.

Not only do the major inherent characteristics of vegetation types influence infiltration and erosion rates, but also the condition of the vegetation found within a type exerts an effect. For example, infiltrometer studies in a grassland growing on soils derived from a mixture of granite and schist show distinct differences in infiltration and erosion rates under different conditions of forage production (6). The infiltration rate of the plots in good forage condition was 118 per cent greater than on plots in very poor, 80 per cent greater than plots in poor condition and 35 per cent greater than plots in fair condition. Likewise, the erosion rate on the plots in good condition was about one-fourth that from the plots in very poor condition, and about half that from plots in fair condition.

The results of this study in a grassland on soils derived from a mixture of granite and schist are tabulated below.

Forage condition class	Average infiltration rate	Average erosion rate[1]
	in./hr.	
Good	2.22	166
Fair	1.64	269
Poor	1.23	699
Very poor	1.02	528

[1]Expressed as pounds per acre per inch of surface runoff.

It is apparent from this study that a good grass cover from the standpoint of forage production also gives the best watershed protection.

Soil characteristics occasionally overshadow the influence of forage condition on infiltration and erosion rates. For example, infiltration studies of a grassland growing on soils derived from biotite schist gave the following results (6):

Forage condition class	Average infiltration rate	Average erosion rate[1]
	in./hr.	
Excellent	0.88	93
Good	1.30	152
Fair	1.77	1,531
Poor	2.06	1,327

[1]Expressed as pounds per acre per inch of surface runoff.

It is obvious that the excellent and good forage conditions excell in the control of erosion, even though they have lower infiltration rates than the fair and poor conditions. Upon analysis of the factors governing the infiltration rates of these soils, it was found that the amount of clay in the subsoil (three to seven inches) accounted for 70 per cent of the variation between the plots. The plots in both the excellent and good forage condition contained more clay in the subsoil than the plots in fair and poor forage condition.

In general, infiltration studies provide the relative infiltration and erosion rates between different vegetation types and between different conditions within the types. They also correlate these rates with soils developed from different geologic materials. The extent of individual "plant-soil complexes" within a particular drainage basin determines the characteristics of the basin with regard to surface erosion and runoff. For example, a drainage basin covered with a grassland growing on soils derived from biotite schist will have different surface erosion and runoff characteristics than a similar basin which is covered with a grassland growing on soils derived from granite. Infiltration studies provide information on the surface erosion and runoff characteristics of the different "plant-soil complexes" and are helpful in determining the reaction of different drainage basins to cloudburst storms of varying amounts and intensities (Figure 5).

The Value of Watershed Management

The infiltration studies in the foothill zone, together with other studies at the Manitou Experimental Forest (5), all show the need for careful use of the forage and forest resources. Excessive removal of the native vegetation exposes the highly erodible granitic and schist soils, and when coupled with intense cloudburst storms, results in damaging floods and destructive sedimentation.

The point at which vegetation can lessen floods and at the same time hold the soil in place is the critical point in watershed management. It becomes more critical when a certain portion of the vegetation is used for economic reasons. The determination of the degree to which vegetation can be used and still be effective in curtailing damaging floods is the objective of watershed-management research. It is the key to the wise use of the foothills of the Colorado Front Range.

Watershed management is closely associated with other uses of the foothill zone, particularly grazing by livestock and the harvesting of timber. For example, based on current market values, the annual return to ranch income is 45 cents per acre more for moderate grazing use than from heavy grazing use as practiced in the experimental pastures at the Manitou Experimental Forest (10). The maintenance of the productivity of the moderately grazed pastures depends upon the maximum absorption of water and the minimum of surface erosion. Here watershed management makes its contribution to range production at the same time that the watershed itself is improved.

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First, and most essential, we must know the physical realities which we face. Too long we have reckoned our resources in terms of illusion. Money, even gold, is but a metrical device. It is not the substance of wealth. Our capital is the accumulation of material and energy with which we can work. Soil, water, minerals, vegetation, and animal life—these are the basis of our existence and the measure of our future.

—PAUL B. SEARS

What Do You Mean: 'Soil Conservation'?

WILLIAM R. VAN DERSAL

Here is the last section of Dr. Van Dersal's report covering the findings of the technical committee on the meaning of soil conservation. In it, he covers the inspirational aspects, troubles ahead, relation to other conservation programs, personalizing soil conservation and some tentative conclusions. It is truly the most thought-provoking study of the subject made thus far.

Already, many persons have written to Dr. Van Dersal expressing their views of the committee's findings. Some are in complete agreement while others differ in their views. Readers of the JOURNAL are urged to carefully review both sections of the paper and express their views in writing to Dr. William R. Van Dersal, Ross Building, 209 S. W. Fifth Avenue, Portland 4, Oregon.

IN THE FIRST HALF of this article, we noted that the term "soil conservation," originally meant "*to keep guard over soil,*" and that this meaning has by now been considerably expanded. With few exceptions all the people who sent in their definitions believe that soil conservation, as they see it, embraces at least three ideas, of which *the first is to prevent land from being damaged; the second is to repair damage already done; and the third is to make the land as productive as possible.*

Some Further Ideas

To carry these ideas further, we may study the meanings attached to soil conservation by others. Dr. H. H. Bennett, for many years chief of the Soil Conservation Service, gave this definition of modern soil conservation in 1949:

"Modern soil conservation is based on sound land use and the treatment of land with all the proven appropriate measures that are needed to keep it permanently productive while in use. It means terracing land that needs terracing; it means contouring, strip-cropping, and stubble-mulching the land as needed, along with supporting practices for crop rotations, cover crops, etc., wherever needed. It means gully control, stabilizing water outlets, building farm ponds, locating farm roads and fences on the contour, planting steep, erodible lands to grass or trees, development of good pastures and good management of them after they have been developed. Modern soil conservation, morevoer, consists of doing these and still other necessary things. Where land is too wet, modern soil conservation calls for drainage; if it is too dry, it calls for irrigation; if it is subject to wind erosion, it calls for stubble-mulch farming, windstripping, and windbreaks. If plant nutrients have been depleted, it calls for fertilization; if water-soluble salts have accumulated in toxic quantities, it calls for leaching out the salts by flooding. And modern soil conservation calls also for the use of the best of the most adaptable varieties of crops as well as the most efficient tools available to farmers.

"And an indispensable part of modern soil conservation is a supporting program of research, such as will provide at all times all the advantages that progressive science can contribute. Moreover, modern soil conservation calls for the continuing maintenance of all effective work put on the land."

Dr. Robert M. Salter, who succeeded Dr. Bennett says in his letter: "I would say that soil conservation is the application on the land of all necessary measures in appropriate combinations to build up and maintain soil productivity for efficient, abundant production on a sustained basis. Therefore, *soil conservation means proper land use, protecting the land against all forms of soil deterioration, rebuilding eroded and depleted soils, conserving moisture for crop use, proper agricultural drainage and irrigation where needed, and increasing yields and farm income—all at the same time.*

"The true conservationist is guided by the basic principle that all land shall be properly used and managed. In terms of agricultural land, this principle is well stated in the words 'The use of each acre of agricultural land within its capabilities and the treatment of each acre of agricultural land in accordance with its needs for protection and improvement'."

Charles F. Brannan, former Secretary of Agriculture, quotes Dr. Salter's definition stated above, then goes on to say: "I know of no truly efficient use of land for the production of food and fiber which does not at the same time help to accomplish the broad objectives

Wm. R. Van Dersal, a member of the SCSA and chairman of its technical committee on the meaning of soil conservation, is Regional Chief of Operations, Soil Conservation Service, Portland, Oregon. Dr. Van Dersal is the author of "The American Land" and numerous books, pamphlets and papers.

of soil conservation. And I know of no truly efficient soil conservation activity which does not increase the production potentials of the land to which it is applied. Such truly efficient uses will also inevitably help to achieve the objectives of good flood prevention and control, power development, navigation and recreation to the benefit of all the people.

"The statement 'the use of each acre of agricultural land within its capabilities and the treatment of each acre of agricultural land in accordance with its needs for protection and improvement' expresses, I believe, a fundamentally sound guiding principle for conservation efforts. This guiding principle applies to the farmer or rancher and also to public or private groups. Furthermore, it has become a matter of common understanding that many conservation problems cross farm, ranch, county, state, or other boundaries established by man. Experience proves that these problems can be practically solved only by concurrent and dovetailed teamwork by all interests involved. Also, knowledge is rapidly becoming common about many other desirable results, frequently considered secondary, which arise from effective conservation on the land. These include flood prevention, improvement of wildlife and recreation, and similar benefits.

"Of course, the end objective of conservation on the land—common to that for all worthy human efforts—is the current and continued welfare of people. I feel sure that soil conservation has already made a major contribution to that end. And, the future contribution, throughout the world, will be even greater."

Troubles Ahead

Finally, Dr. Charles E. Kellogg, now assistant chief of the Soil Conservation Service, but writing at the time he was chief of the Division of Soil Survey of the Bureau of Plant Industry, Soils, and Agricultural Engineering, had this to say: "It has seemed to me that the concept that we really want is expressed by the words '*efficient sustained production.*' Unfortunately, there is no single word in English with that meaning. Dr. Salter, in his speech at Des Moines last winter, suggested that we define soil conservation in essentially those terms. I have come to the conclusion that it may be our best way out, although we must expect a lot of confusion. Thus 'soil conservation' might be defined as the development and maintenance of soil-use systems that lead to efficient sustained production."

That these ideas will give us trouble seems clear, as Dr. Kellogg goes on to point out. "No matter," he says, "how we ourselves undertake to define the expression, other people will continue to use it in the very narrow sense of erosion control and in the sense of many transitions between that and the broad concept. Furthermore, it is used now only rarely in the literature in the sense I am proposing as a possibility. If this broader definition is accepted—and I am not entirely certain that it should be—then all of the books I know that have the expression 'soil conservation' in the title are misleading since they deal primarily with control of runoff and erosion.

"I think your committee needs to give the various alternatives a great deal of study and be fully aware of the implications of a broader definition and of the great difficulties in getting general acceptance. Under a broad definition it would not be appropriate to use an expression like 'conservation practice' to specify one that is primarily designed to avoid erosion losses. Under the broad definition we are discussing the appropriate use of supplemental nitrogen on corn on level land would be just as much a 'conservation practice' as any other practice involving good husbandry. This would make obsolete many of the terms that have become commonly used in our agricultural programs of both the Soil Conservation Service and the Production and Marketing Administration. Perhaps if we broaden our definition of soil conservation, we might be able to find some other term, some more narrowly defined term, to use for what many people now call 'conservation,' 'conservation practices,' 'conservation farming' and so on.

"I might say too, that Dr. Salter and I have discussed this a great deal, and I know of no differences between us. I think it is fair to say that we are both a bit worried about the adoption of a broad definition of soil conservation as '*efficient production on a sustained basis*' and at the same time have many people still using the term 'soil conservation' in the narrow sense of runoff and erosion control."

Inspirational Aspects

We come next to a number of letters containing ideas by no means as easy to classify as the ideas expressed so far. Everyone at all close to soil conservation work in the United States must have been touched to some extent by the inspiration of the great movement. Certainly a great many people become, as it were, crusaders who are almost passionately moved by the idea of protecting, restoring, and improving soil, the food-producing basis of our civilization.

For example, Waters Davis, Jr., president of the National Association of Soil Conservation Districts, says that "Soil conservation is a state of mind that leads people to treat and use the land in harmony with nature's relentless laws."

Mrs. L. J. Francke, president of the American Federation of Garden Clubs, writes that "I personally think

that the spiritual side of the question is as important as the physical. In every family that I have met through my trips with Friends of the Land and with the Soil Conservation Service, I observed the uplifting effect of the work and results on the women and children as well as the men who responded to the call to think of the next generation, and the next,"

George Peterson, associate editorial editor of the Minneapolis *Star*, writes, "Maybe I had better just tell you how the subject affects me. First, there is a conviction that virtually all of life stands or falls on what happens in the soil. . . . I think this earth faces a desperate struggle—and long has been waging one—to support its people. And that does not mean only to feed them at a subsistence level, but to give them adequate food and shelter—all of which comes out of the soil to a large extent."

"Soil conservation in a very great sense encompasses for me the whole meaning and pattern of life. Being associated with it has meant for me a lifting of the spirit and nothing would induce me to end the association."

Donald Pharis, conservation farmer at Liberty, Missouri, writes, "Soil conservation should mean *loving* the land so much that you do all you can to preserve and improve its productivity. The true soil conservationist is thinking of the welfare of others *now* living, and of those to come; of the nation which he loves, and expects to protect him and his family. He knows that all strength comes from the soil. He receives great pleasure in seeing and living on his well cared for, productive fields. He is deeply hurt when he sees the neglected, eroded fields of the ignorant or selfish soil wasters. Soil conservation usually results in more prosperity for the farmer, but this profit motive is last. There are many reasons and motives for conserving our soils, 'But the greatest of these is love!'

"This makes up a rather long discussion on the subject, which can be cut down to its essential idea of affection for the land, with that motive being the uppermost one, in a few words. I get tired of hearing the profit side of conservation being pushed and talked almost exclusively. It's time we farmers were learning to care for the land because of the love we have for it, as the source of all things beautiful as well as most things useful."

Quoting E. O. Moore, of New Mexico, again: "There is still another thing that Soil Conservation *is*. It is an opportunity to us farmers who work in soil conservation districts to satisfy our earnest desire to be of value in our various communities and collectively to be of service to our entire country and possibly to the whole world. It is an opportunity for us to store up a kind of wealth that proves our own integrity; following the rule that was outlined some time ago for true leadership: 'He that would be greatest among you, let him be the servant of all'."

Finally, W. A. Rockie, soil conservationist emeritus and author, writes, "As I visualize the soil conservationist—what he is, what his objectives are, and what soil conservation will accomplish—I think of him as having a rather different concept of the land and its problems than the usual agricultural technician. I think he understands the land better, and is endeavoring to keep man and nature more nearly in harmony, and to avoid open conflict between the two."

REPRINTS. ***Individuals, SCSA Chapters and other interested groups may obtain reprints of "What Do You Mean: 'Soil Conservation'?" at the following rates: Single copies—10 cents each. In lots of 100—$8.00. Requests should be addressed to H. Wayne Pritchard, Executive Secretary, Soil Conservation Society of America, 1016 Paramount Building, Des Moines, Iowa.***

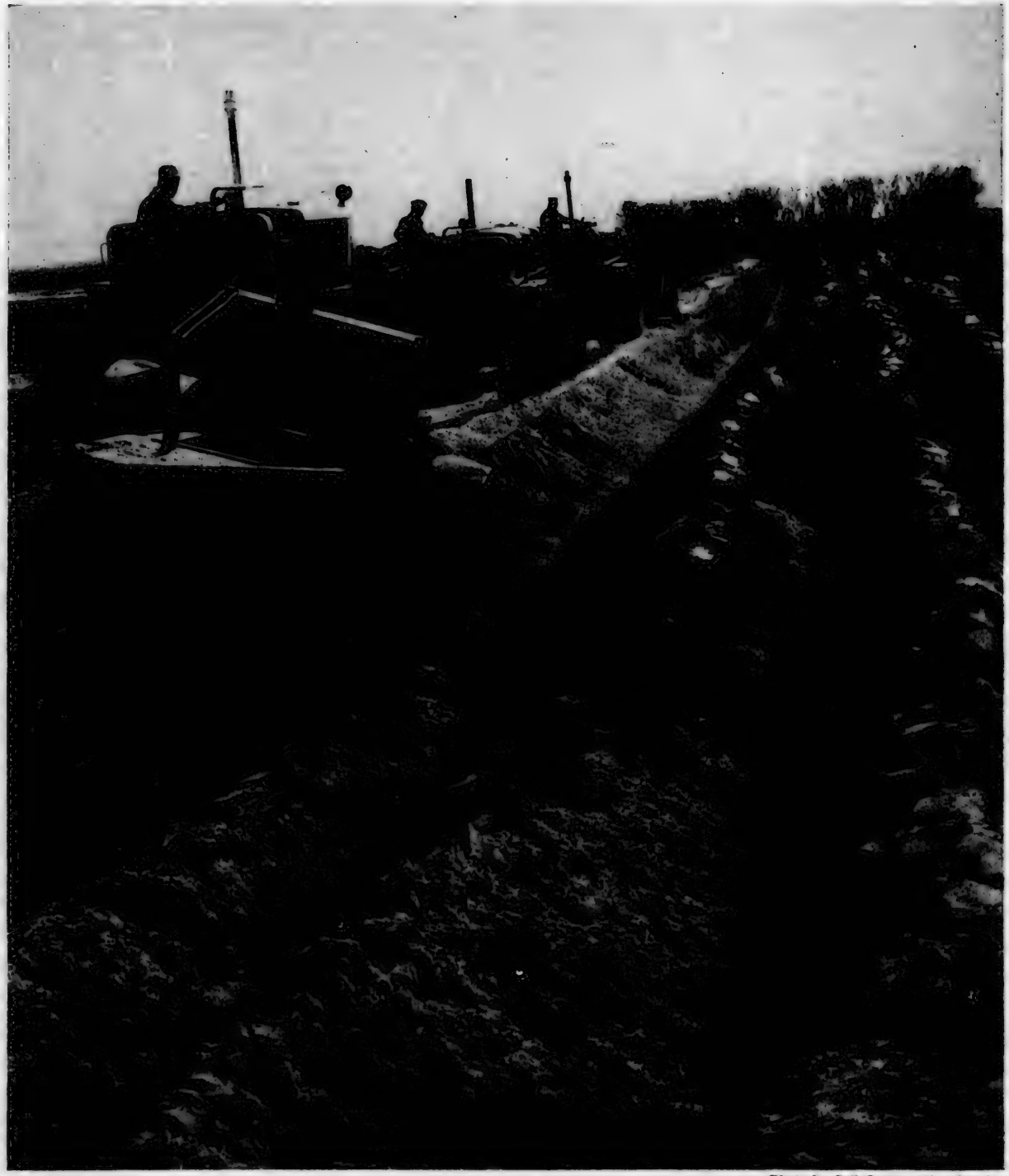
Personalizing Soil Conservation

Lester C. Lutes, former newspaperman and now successful conservation farmer, writer, "You want me to define Soil Conservation. To do so I could oversimplify and get out of this job easy. Soil: an agglomeration of mineral particles and the residue of decayed organic matter, common as dirt. Conservation: to save. Soil conservation: save dirt.

"Since you obviously want more than this, you put upon me the onus of describing a way of life, with my personal experiences of it, which dangerously widens the field of possible error.

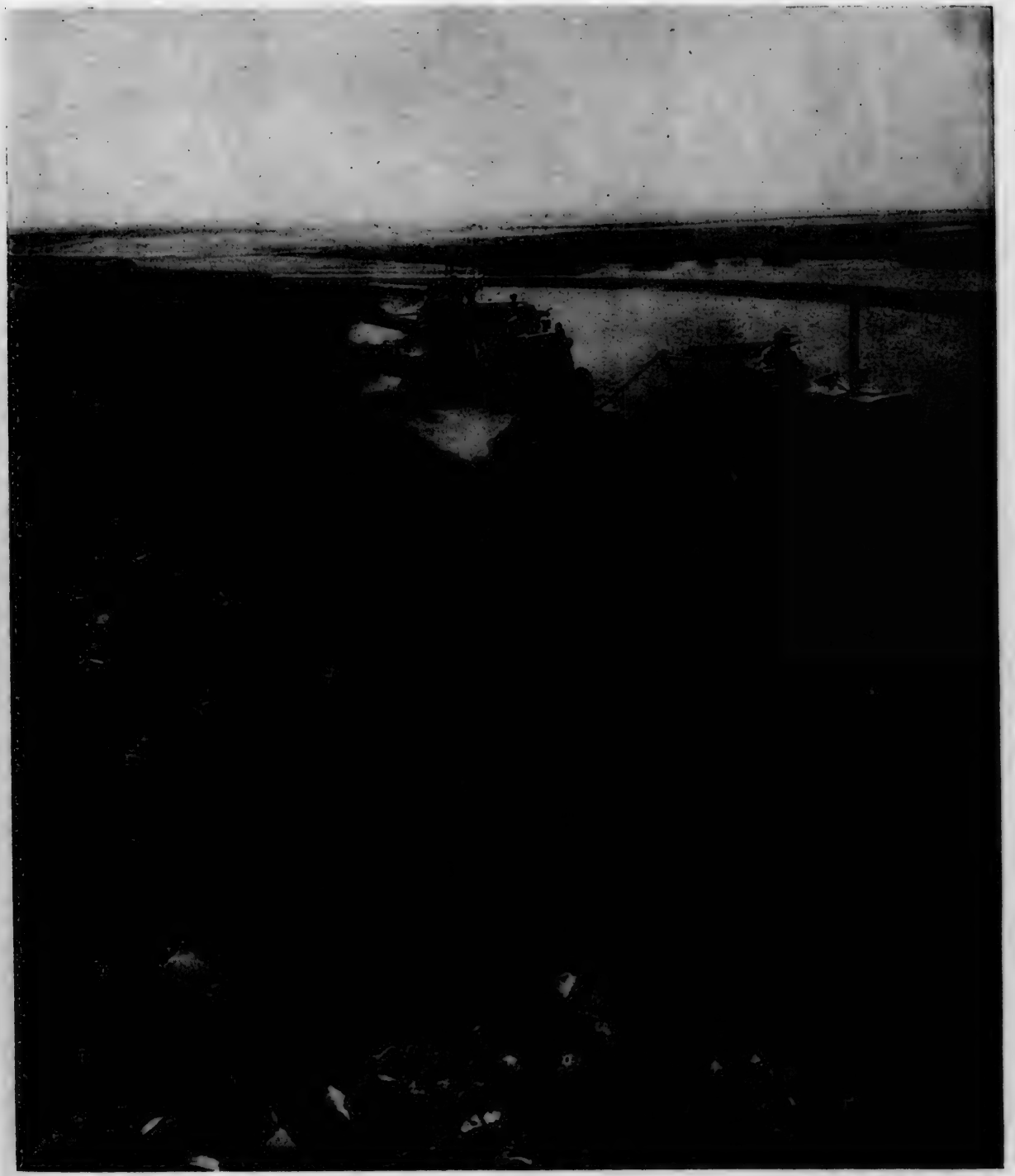
"Mom and I and the boys deserted a small town newspaper in 1940 for 240 acres of rolling, badly-eroded northwest Missouri land, complete with mortgage. We knew nothing whatever of Soil Conservation and very little about farming in general, though Mom was a farmer's daughter. We were looking for a place to keep the boys busy, and I believed an old gentleman of the community who said that 'farming is the noblest occupation of man.'

"The keeping-busy part of the deal was a success from the start, but our moving in the purple and ermine set of the nobility was unaccountably delayed. We were bright enough to see what was wrong, but not to know what to do about it. We tried. We doodle-dammed some ditches, and subsequent big rains made them wider and more cooked than before. We curved the corn rows around the hill by dead reckoning, and they concentrated the water in old plow dead-furrows, and our scant remaining topsoil went merrily off. By the time



—Photo by Soil Conservation Service

This operation shows deep plowing of sanded land near Manhattan, Kansas. Sand deposited by the Kansas River flood-waters on this land averaged about 24 inches deep. The four-foot moldboard plow required for the plowing job was pulled by three heavy tractors.

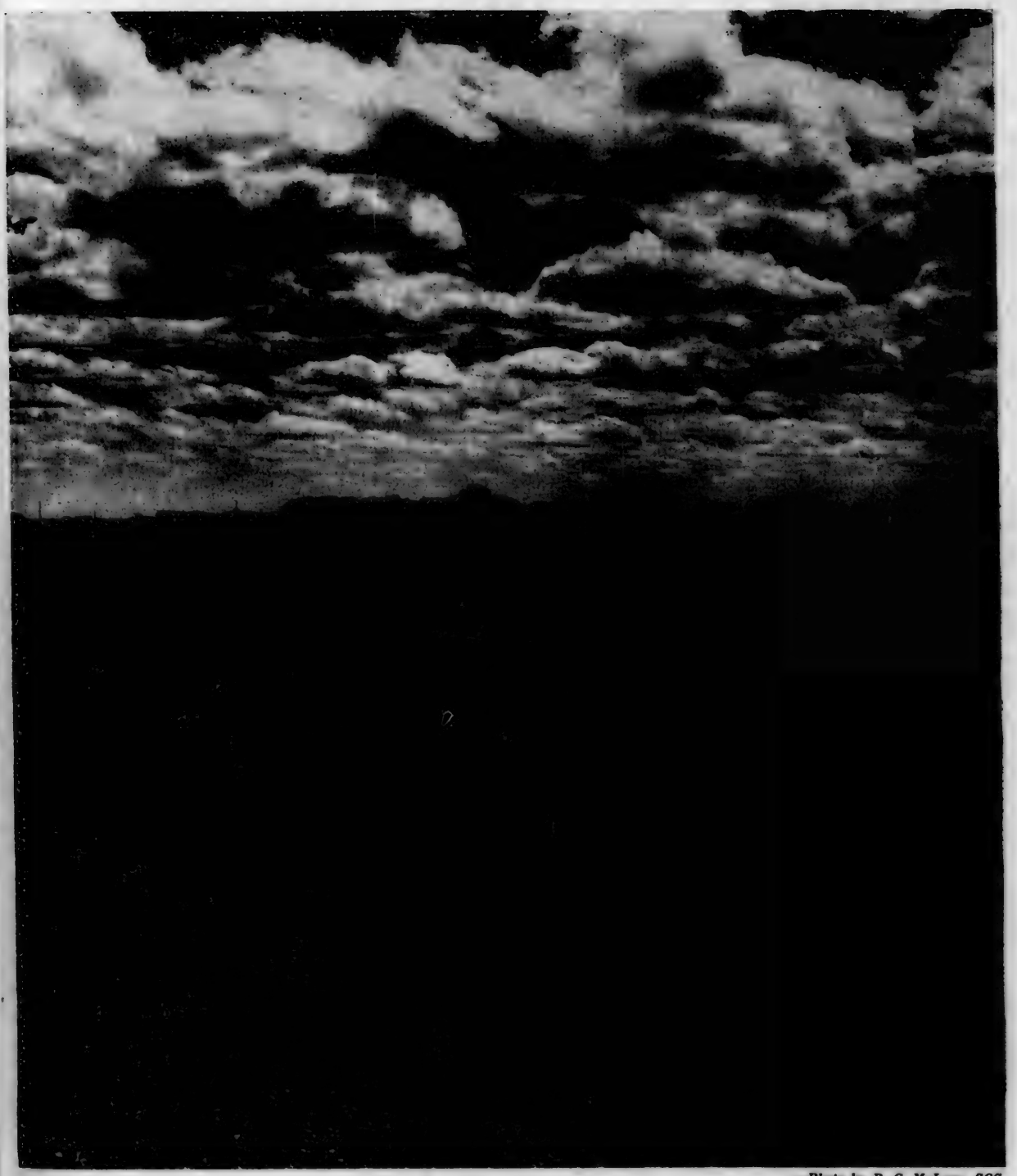


—Photo by B. O. McLean, SCS

These level terraces are being constructed with a Hancock elevating belt. The contractor, under whose direction the work is being done, estimates that the three machines could, on favorable ground, construct a one mile terrace in three and one half hours.

—Photo by John W. Busch, SCS

Pasture irrigation is rapidly being expanded in many sections of the country. Water for this pasture near High Point, North Carolina, is being taken from a farm pond.



—Photo by B. C. McLean, SCS

This wildlife planting area near Amenia, South Dakota was made in 1948. It consists of Honeysuckle, Buckthorn, Caragana, Persian Lilac, Sandcherry, Plum, Chokeberry, Crabapple, Apricot, Dogwood, Russian Olive, Buffaloberry, Ash, Boxelder and Cedar. The waterway is seeded to brome grass.

the Soil Conservation District of Worth County was formed here in 1944, we had abandoned the hillsides and were farming only the ridge tops. This was all right except we weren't raising enough, and the ditches didn't cure themselves.

"The new conservationist came out and deviled us about such matters as terraces, waterways, tube structures, etc., 'til we signed a farm plan. We decided to go along, but with a good many mental reservations. Even after we were pretty well along with building a water control system, he kept coming up with some of the dizziest ideas. One of the prize ones was pasture.

"If we had a strong point it was pasture. Ours was virgin, never having been plowed in the memory of the oldest neighbor. True, it was green only during May and June and consisted mainly of buck brush, ragweeds and elm sprouts, and our 14 cows never seemed to put on much flesh, but it was undoubtedly good ground. Finally, with ride and dinner furnished, I went on a trip to Clay County, down by Kansas City, to see what they called 'pasture renovation.' Two weeks later we owned a heavy brush disc and a fertilizer spreader to go with our terracer and small dozer, and were finding out about such things as the proper seed preparation of alfalfa, brome and ladino.

"Further recital of our slow climb against the innate knotheadedness of man would be wearisome. Let it suffice to say that this winter, with our program about half completed, we are carrying through 43 black cows and 2 Jerseys, 43 yearling calves and about 50 sheep. We sell about 200 hogs a year. All the stock and all their feed, winter and summer, are raised on the place.

"The personal results of Soil Conservation are at least satisfactory. Mom has as many and shiny gadgets in her kitchen as any of the town girls. If she wants to go down to the city and spend a cow on a new outfit it is okay, for there are plenty more at home knee deep in good feed. The boys are grown now and Jim is a sophomore at Oklahoma A & M, and high school Bill takese about as good a car as there is in the county when he goes out Sunday nights. For my part I get mine out of looking at the waving glossy green of a hundred bushel cornfield, the lush growth over the healed scars of old gullies, and the knowledge that my kids and their kids too, may if they like, live and prosper on these same acres. This is our definition of Soil Conservation."

Relation to Other Conservation Programs

It has been obvious for a long time that the installation of a soil conservation program on land has many important secondary effects particularly with respect to other resources deriving from land. Many measures taken for the conservation of soil and water are identical, or essentially so, with some of the measures taken to conserve forests, grass, wildlife, or other crops. The only difference between them, possibly, is the intent of the land-user when he installs them. The planting of trees can be either a soil-conserving measure, a flood-prevention measure, a forest conservation measure, or a wildlife conservation measure—although actually it is all of these. Attempts to distinguish between these measures would seem to have little value.

But, to achieve full-scale conservation of wildlife or trees, for example, additional measures are required that are certainly not identical with soil conserving measures. Their objective is the conservation of the products of the soil, but benefits to the soil are secondary. Thus, the pruning of trees, valuable from a timber crop standpoint, might be designated one measure that helps result in forest conservation. Leaving the lopped limbs on the ground, to add to the humus, certainly of value from the soil conservation point of view, is secondary in character. In a general way it may be said that when we begin working primarily with products of the soil, we are entering another field of endeavor than soil conservation, despite the fact that the relationship may be very close and that the one depends upon the other. We cannot, therefore, logically label everything done to enhance and improve the crops or products of the soil as soil conservation.

Insofar as water is concerned, a review of the letters quoted earlier suggests that the idea of water conservation must be included in the term soil conservation. Some letters mention this specifically and many others imply it. Certainly water is as much a component of soil as are minerals, organic material, or the fauna and flora inhabiting the soil. Measures taken to conserve soil not only involve the application of water to it (irrigation), and the removal of water from it (drainage), but also these soil-conserving measures are intended to affect the amounts of sediment carried away by water as well as the amounts of water stored or held in the soil.

On occasion valiant attempts have been made to distinguish between measures for soil conservation and those for flood control. These attempts have been stimulated by appropriating bodies, who, when they appropriate money for flood prevention, presumably do not want merely to enhance a program of soil conservation. What they want is a clean-cut program of flood prevention clearly distinguishable from other programs. For reasons noted in the preceding paragraph this is not easy to do on any given parcel of land. When measures installed can be shown to have effects over and above those needed for soil conservation, and the results are primarily to be obtained in the impoundment or holding back of free water, then we may be said to be clearly in the flood

prevention field. Even so, in the beginning, measures placed on land may have equally beneficial results, both for soil conservation and for flood prevention. Parenthetically it may be noted that full protection of the watershed does not control floods. Some, but not all, raindrops can be caught where they fall.

Summary

We may now return to our original question: What *is* soil conservation? From the cross-section of opinion we have, it is possible to say that:

1. Soil conservation is *not* protecting or defending soil from use.
2. Instead, it involves the idea of *use,* with the minimum of damage or waste.
3. It is *not* safely described as wise use, because we are uncertain as to whose wisdom we should rely upon.
4. It involves water as well as soil, since water is an inseparable part of soil.
5. It is *more* than erosion control or prevention, but it *does* include this idea.
6. It involves repairing land damage that has already occurred, including the restoration of soil fertility, structure, and other properties.
7. It involves the idea of making the land as productive as we know how, and therefore implies an abundant production.
8. It suggests the idea of *profitable* use of land.
9. Its meaning seems to include the idea of good husbandry,—a very old terms with connotations of frugality, thrift, and wise and skillful management of land.
10. It involves the idea of using land in accordance with the capabilities of land for various uses.
11. It includes the use of a variety of measures in combinations that depend on the needs of the land for protection and improvement.
12. It involves the idea of *efficiency* in use and treatment of land.
13. It requires the application of science, skill, and experience to solve land use and management problems.
14. It is a long-range process in some of its aspects.
15. It is closely inter-related with other programs, such as the conservation of forests, grass, and wildlife, and the prevention of floods.
16. It often requires teamwork by land-users, as well as individual effort.
17. It seems to engender a crusading spirit or attitude on the part of the people who practice it, and to give rise to a number of inspirational ideas, such as loving the land, preserving the land for future generations, harmonizing man and nature, lifting the spirit, providing an opportunity to be of service, and the like.

Tentative Conclusions

All that seems necessary at this point is to condense the first 14 of the above 17 items into a simple phrase. (Items 15 and 16 are facts but they are not exclusive or limiting and hence need not be a part of our definition. Item 17 has to do with the pleasures and attitudes of mind of those engaged in soil conservation).

I submit as chairman of the "committee" struggling with this problem, that the condensation may be desirable, but it is well-nigh impossible. However, I offer tentatively this long definition:

> ***"A system of using and managing land based on the capabilities of the land itself, involving the application of the best measures or practices known, and designed to result in the greatest profitable production without damage to the land."***

Shortening this definition leads to:

> ***"The most efficient known system of using and managing land for maximum profitable production on a sustained basis."***

A soil conservationist, then, would be one who uses, advocates the use, or directs the use of a system of using land, etc. A farmer using such a system would clearly qualify. So would a scientist or technician of any kind who was professionaly contributing his knowledge and experience to furthering such a system. So, also, would a teacher or an administrator or supervisor of such a system. And a soil conservation practice would be one that is used as part of a system of using land in the manner described.

. . . a free and wise society must expect the educator to point courageously at the faults from which it suffers, and to seek remedies for them. —Robert Ulich

A New Stage in Resources History

GILBERT F. WHITE

The United States appears to be entering into a new stage in the history of its development of naural resources. This current change is suggested by some of the major understandings that come from recent government reports.

The broad pattern of water development is being frozen for a good many years to come. Demand for raw materials is rising and is expected to continue. While the United States has shifted from being a net producer to a new consumer, it has assumed new responsibilities for resources development overseas. For the first time for most materials the real cost of production has begun to rise.

The changes make it important for business groups to take a more direct part in conservation efforts than they have to date, and to lend their support in several specific ways. The following paper is the summary of a talk given to the Conservation Conference for representatives of Michigan business interests last May.

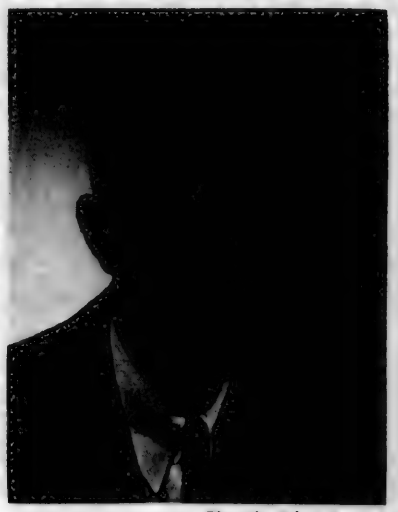


Photo by Fabian Bachrach

Gilbert F. White

THE PAST FIFTEEN years have seen a momentous change in the resources situation in the United States. Domestic resources development has entered a crucial stage in many areas. Long-run trends in the production of basic materials have been reversed. The United States position in the world market has altered rapidly and radically. New ideas as to resources use and management have begun to replace ideas which have prevailed for half a century.

The combination of these events—some the result of advancing technology, some the result of a chaotic world situation, some the product of widely increasing pressure of population upon the land—gives the United States a new prospect for the wise development and use of its natural resources. This picture is extremely complex, but a few major elements can be seen clearly. At the risk of over-simplifying, it is possible to point out a number of the events that have combined to create this new prospect. Most of the relevant facts are presented in a series of reports issued during recent years; the President's Materials Policy Commission (Paley Report (1), the President's Water Resources Policy Commission (2), and the proceedings of the United Nations Scientific Conference on Conservation of Resources (3). These draw together a great deal of previously disperse thinking and statistics. Some of their estimates are rough guesses at best, and many of the recommendations in them are highly controversial, but there appears to be wide agreement on a few of the facts.

From them an outline of future development begins to emerge which has a special relevance for representatives of business, industry and finance. In the new picture business groups have, it would seem, a more direct stake and a clearer responsibility for action than in earlier decades. No doubt the very fact that this conference is taking place this week indicates a recognition by business groups of changes that have already occurred.

The prospect which we now face is not as discouraging as that presented in some of the recent conservation literature which ominously maintains that the United States itself already is over-populated in terms of the available resources, and that other densely-settled areas are explosively over-populated unless drastic measures are taken to curb population. At the same time the evidence does not seem to support the assertion by some business leaders that given freedom of research and enterprise, and stable investment possibilities, there is no need to fear any shortage of materials. It seems neither as hopeless nor as hopeful as these views would suggest.

Freezing the Pattern of Water Development

One recommendation in the report of the President's Water Resources Policy Commission was that new water projects in the United States should be undertaken only as they are clearly shown to be in conformity with drainage basin plans that have been restudied and approved. The Commission found that the cost of Federal projects under construction or authorized was equal to

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the entire cost of all Federal projects constructed in the preceding one hundred and sixty years. Projects planned but not yet authorized would have a minimum cost at least four times as great.

Many of these projects had been planned without adequate basic data on water, land and mineral resources. Most had taken shape while the experience from the pioneering efforts on the Columbia, the Missouri and the Tennessee was still undigested. It seemed desirable to take a fresh look at the schemes for development of other basins before letting them reach the construction stage.

There is a sobering finality in river basin development: once a major construction plan is undertaken little can be done to change the pattern of water use which it imposes upon the surrounding area. A dam cannot be moved and there are relatively few suitable damsites. Irrigation projects cannot be shifted merely because the soil turns out to be unproductive. Once a commitment is made to protect a city from floods it is extremely difficult to withdraw from doing whatever is essential, regardless of costs.

In its river development the United States has entered into a period which is similar to the great transcontinental railroad building period which followed the Civil War. Heavy investment is being made in new dams, power plants, navigation facilities, and levees which when completed will fix the main outlines of economic development for decades to follow. When these works are done the pattern of water development in the United States will be frozen as surely as the pattern of transcontinental freight traffic was frozen by the turn of the century. There still will be opportunity for competing facilities, and for extensions and changes in the pattern, but the major outlines will remain.

Only a few basins such as the Tennessee are fully developed with river-regulating works. There still is time to make changes in the present plans of the other basins if it seems desirable. The time is short. Each year sees new plans authorized and new commitments made. At the present rate of construction the next twenty years will see the major part of the job done. Students entering into business and professional life this summer will witness in their active lifetimes the completion of large-scale water development as we now envisage it. Whether or not that development is sound will depend upon review and appraisal during the years immediately ahead.

For example, the present Federal policy for dealing with flood damages lays heavy stress upon engineering works to curb and delay flood flows. Minor attention is given to land-treatment upstream, and little or no attention to such alternative means of reducing flood losses as emergency evacuation, relocation, readjustments in land use, and zoning. If these alternatives are ignored for the next few years the Federal commitment to protect people who own property or live in the major floodplains will be so heavy that there will be little point in considering cheaper or more effective action.

Accelerated Increases in Demand

The past decade also has brought tremendous increases in the demand for certain raw materials. In the Paley Report an effort is made to forecast the consumption of raw materials in the decade 1970-80, choosing a period of approximately 25 years in which the current defense production problems hopefully will become less dominant and in which many technological shifts probably can be forecast.

If it is assumed that by 1975 the total population will increase to 193 million and that total national output will be twice the 1950 level, and if it is assumed that the relative prices of various materials remain unchanged from 1950, projections can be made as to the demand for basic raw materials. These projections by the Commission show that considerably less than a doubling of total materials input will be needed to support a doubling of national output. The Commission believes that a 50-60 per cent increase in total materials production will support a doubled national production.

The demand for all materials is expected to rise, but the rate of increase for some materials will far exceed others. The Commission published estimates as to prospective changes which are highly controversial and have been widely challenged, but a few of them may be quoted here to indicate the magnitude of development anticipated by the Commission. By comparison with 1950 consumption, tin demand is expected to increase 18 per cent and iron ore 54 per cent. At the other extreme, among the minerals, petroleum is expected to increase more than 100 per cent and aluminum more than 291 per cent. For products of the land, excepting forests, an increase of 40 per cent in demand is anticipated. Timber product demand is expected to increase by about 10 per cent with major changes taking place among timber uses. Obviously, a great claim is likely to be made upon all of our natural resources during the decades immediately ahead.

Water supply illustrates one of the materials which has been considered abundant but which may be in short supply over large areas by 1975 unless prompt measures are taken. Consumptive use of water for municipal, industrial and irrigation purposes has mounted at a rapid rate and promises to continue to rise. Approximately 185 billion gallons were used daily for those purposes in 1950. Within the next three decades this use is expected to mount to 350 billion gallons daily. The greater

part of that 90 per cent increase is expected to take place in the industrial field. There the trend is not alone to use more water but to make more exacting requirements of water free from organic and inorganic impurities, as shown in the recent report by the Conservation Foundation (4). Demands upon groundwater have tripled since 1935. This trend will continue so long as pollution of both surface and underground sources is not curbed more effectively. It must be asked, however, whether the surface and ground supplies can meet the prospective demand. It is common knowledge that there now are large sections of the United States in which certain types of industrial development are impracticable because of the inadequacy of existing water systems.

In the case of water, as with the other less abundant materials, it is difficult to offer any simple solution for meeting the forecast demand. The size of known reserves, the cost of substitutes and improvements, the possibility of technological improvements, and the availability of the same or substitute materials outside the United States must be taken into account.

Net Producer to Net Consumer

In 1950 the United States, with 9.5 per cent of the free world's population, and 8 per cent of its land area was consuming half the volume of the free world's production of materials. It had arrived at this position by making huge increases in its use of materials: in the preceding 50 years bituminous coal consumption had increased 2½ times, iron ore 3½ times, zinc 4 times, and petroleum 30 times, as compared with 1900. Minerals as a group increased much more rapidly than either agricultural or forest products.

The effect of this extraordinary growth in materials use was to change the United States trade relations with the rest of the world in at least two important respects. *First,* the country, after having had a production surplus of 15 per cent in 1900, had developed a production deficit of 9 per cent in mid-century. After having been a net world exporter of copper, petroleum, zinc and lumber, during the late 30's or 40's the United States became a net world importer of those and other key materials.

Second, the United States was using up its known reserves of such materials at a much higher rate than other countries in the free world.

The result of this great period of use of natural resources was to make the United States the dominant user in the free world market, to change it from being an exporter to being an importer, and to use up its reserves more rapidly than the other countries. Paley Commission projections of possible production and demand for 1975 suggest that this shift will continue, and that by that time the annual production deficit will be in the neighborhood of 20 per cent.

Reversal of Real Costs

Even though the materials consumption sky-rocketed during the first half of the century, the real cost of producing most of the materials declined. That is, the hours of human work and the volume of capital required to bring a unit of material into use decreased. The Paley Commission tried to estimate these "real costs," expressing them so as to eliminate the major effects of changes in current dollar values. Thus, labor time required to mine a ton of bituminous coal declined from three hours and 20 minutes in 1903 to one hour and 20 minutes in 1950.

This decline in most of the materials industries was made possible by new technology, by heavy investments of capital and energy, and by drawing upon the cheaper sources of supply. In general, the supplies of minerals and land most fully exploited were those which were available at the lowest cost. All through the early decades of the century the cost of materials in relation to general price levels tended to diminish. In 1900, *"each dollar of raw materials cost supported $4.20 worth of finished goods and services; by 1950 the raw materials dollar was supporting $7.80 worth (after discounting for changes in the general price level)."* We were skimming the cream and it was both rich and cheap.

Then in the 1940's, the trend appears to have reversed. The metals, fuels and agricultural industries began to experience a change which long before had set in with the forest products industries: real costs began to rise or to level off. The chemical industry was the only major one in which real costs continued to decline rapidly. Part of the cause for this otherwise general reversal in trend is laid by the Commission at the door of slowness in readjusting to changes in market conditions following the war. Much of the cause lies in the increasing demand for production from dwindling and high cost supplies.

If, as seems likely, this upward trend continues, we will witness a strategic change in the natural resources situation in the United States. The fact that forest products have suffered from rising real costs since the beginning of the century may help explain the heavy emphasis which foresters in both government and private industry long have placed upon conservation practices.

A New World Position

In seeking to find the right course of action in meeting the prospective demands in each resources field, there is a wide range of choice. In general, the Paley Commission seeks to suggest ways consistent with the methods

of free enterprise, the profit motive, and the price system, but it also suggests helps and restraints from government to keep the system working well. Some of the measures considered include promoting more mineral exploration, preventing waste in use, developing lower-quality reserves, encouraging sustained-yield management of renewable resources, and perfecting substitute materials. Possible ways of reducing or shifting demand also are reviewed. Another major opportunity lies in the direction of imports from overseas producers.

Here, account should be taken of a wide shift in the United States position. At the same time that the United States has attained a position of world political dominance it has become more dependent than ever before upon other countries for raw materials, and it has assumed heavy moral responsibilities for resources development in other countries. Part of this new responsibility stems from American investment in producing facilities such as the oil refineries in Saudi Arabia. Private investment thus far has been relatively small because of the uncertainty of world markets and because of the political instability of many of the nations involved.

The larger part of the new moral responsibility attaches to government support of both United Nations and bi-lateral technical assistance work in underdeveloped countries. Those nations are undergoing profound economic and social revolutions leading to radically different forms of both production and consumption. Much of the Point Four work relates to the spread of technology for resources use, and involves the United States in efforts to improve production methods, open up new resources, promote the public health, and introduce new consuming habits.

Often public support of technical assistance in underdeveloped areas is justified either as a necessity of military strategy or as an essential feature in the program to restrict and turn back Communism. Both arguments now find rather wide public support.

There are, however, two other grounds on which vigorous American action in that direction may be expected even though there happily might be an unexpected relaxation of the international political tensions and in the accompanying military preparations. So long as the United States faces an increasing dependence upon overseas areas for basic materials—and self-sufficiency seems both economically and physically impossible—it will be involved in the maintenance and stability of those areas. Much more basically, so long as the United States wishes to act in a spirit of Christian and democratic friendship toward its fellow nations it must be prepared to share in their efforts to improve their own positions.

This commitment has far-reaching implications for our current resources policies. For example, the newly independent countries of Southeast Asia are joined in a program for mutual economic development known as the Colombo Plan. Expenditures of approximately five and one-half billion dollars over a six-year period are contemplated to bring 13,000,000 acres of land under cultivation, to increase the production of food grains by 6,000,000 tons, and to increase electric generating capacity by 1,100,000 kilowatts (5). It is not certain that these results will be obtained. At best, with a completely successful program, the net will be to maintain the status quo in the Southeast Asian area. Population is increasing so rapidly that improvements of this size will only serve to support the new population at the present low standards. Serious famines will remain a hazard. The situation is not hopeless, but drastic efforts on the one hand to curb population and on the other hand to build industrial and crop production will be required for a long time to come. As a minimum this will demand contributions of American equipment and personnel. As a maximum it may demand foodstuffs and producers' goods to help carry the area over crisis periods.

Industrial Analysis

Out of the recent studies that have been made of resources problems has come appreciation for a relatively new kind of thinking as to lines of constructive action. More and more, the problems of an industry are being viewed as a whole, with attention to ways of coordinating different groups of operators.

The forest products industry is a case in point. From the Paley Report it may be learned that the principal problem in looking to meeting future timber demands is in promoting sustained-yield management by the small land owners who hold more than half of the total commercial timber area but who for the most part manage poorly if at all. The large private owners and the public agencies are responsible for the best management. Increasingly, the proper management of the large tracts requires cooperation between public and large private owners, and for the welfare of the industry as a whole the smaller owners must somehow be related to the large operations if supplies are to be used cheaply and efficiently. In dealing with forests, the Paley Report summarizes the results of previous surveys, but it pioneered in dealing with some of the other materials industries in a unified fashion.

It is interesting that the report dealt with energy sources as a group, recognizing the high degree of dependence there is among the coal, oil, gas and hydro sectors of the industry in meeting total energy needs. The Paley Report is bound to stand out as a landmark

in thinking about resources problems because of its relatively successful effort to deal with total demand and total supply for each of the basic raw materials. A new type of analysis is established for industries as a whole.

Multiple-use Administration

The past twenty years have marked very wide recognition of the multiple-uses which resources may have. In Michigan there has been an effort over a much longer period of time to show the close inter-relation of agriculture, forestry, wildlife management, recreation and minerals use in areas such as those adjoining this meeting place. Increasingly, within local areas resources use is seen as multiple-use.

There have been numerous attempts to translate this concept of multiple-use into administration of government or cooperative enterprises for resources management. By and large, the Federal government has failed in its attempts. With the exception of the Tennessee Valley Authority, which has no clear local roots and which operates largely independently of other Federal agencies, the tendency has been for each department to go its own way. Efforts have been made by individual departments, such as Agriculture and Interior, to coordinate their own bureaus' activities within certain regions, and there is an informal inter-agency committee on river basin development, but no thoroughly satisfactory devices have been found thus far.

The soil conservation districts which have been organized under State law with local responsibility probably have proved the most effective agencies in helping private operators deal intelligently with resources problems. A number of watershed associations, of which the Brandywine is the most publicized, are being organized and are beginning to find their halting way in coordinating public and private work. In the water field there has been strong support for local administration of new Federal projects but very little interest in the suggestions made by the President's Water Resources Policy Commission that local beneficiaries should bear a larger share of the construction cost. Sharing of cost and sharing of responsibility go hand in hand.

It appears that new administrative organization is likely to unfold in the years immediately ahead in order to assure the kind of wise multiple-use which now is an ideal rather than a reality. The local efforts, such as the soil conservation districts, emphasize authority resting in local owners, township commissioners, county boards and the like. The new emphasis on coordinated industrial programs in the Paley Report attacks the problem from the standpoint of national goals and responsibilities. Both are necessary and are antidotes for undue emphasis on the other. The local administrative agency does embody, however, a point of view which seems absolutely essential as this country looks forward to enlarged production in a radically different situation than that which prevailed 20 years ago. This is the view that our central concern should be with the quality of individual and family life enjoyed by the people who use the resources.

Emerging Responsibilities of Private Enterprise

These events add up to a formidable and challenging combination of circumstances. They suggest that this country is at a major turning point in its resources history. The pattern of its full water development is beginning to freeze. Demand for many basic materials, including such presumably abundant materials as water, is turning sharply upward. From being a net producer of raw materials the United States has become a net consumer. At the same time the real costs of production have, after a long period of persistent decline, begun to level off or increase. In its new position as a world leader the United States has assumed heavy responsibilities for promoting and cushioning the shocks of profound changes in resources use in underdeveloped and heavily populated countries overseas. A new concept of the coordination of demand and supply factors in basic materials industries has begun to take hold. New administrative devices to deal with genuine multiple-purpose use of resources are being tried on a broad scale.

It could be fairly said two decades ago that while a representative of a large business enterprise might feel a responsibility as a citizen to prevent undue waste in resources use he could show very little reason for committing his business to a conservation effort. The future was too promising: demand did not exceed supply; costs were decreasing; overseas supplies offered opportunities rather than responsibilities. It was left chiefly to the government and to civic groups to deal with local emergencies of resources exhaustion or to attempt to probe the future.

This has changed. Today, a good case can be and is being made for direct participation in conservation work by business. Rather than working against government it means working with and through local, state and federal agencies

Some of the specific ways in which business can act already have been implied and may be noted briefly here:

1. Seeing to it that new investments—public and private—in water resources will yield sound returns.

2. Preventing the unnecessary waste or impairment of materials such as water for which greatly increased demand seems certain.

3. Finding ways of checking the rising costs of production from dwindling supplies of minerals and land.

4. Analyzing the resources position of entire indus-

(*Continued on page 248*)

Resources for Freedom: The Report of the President's Materials Policy Commission

L. G. HINES

In June, 1952, after a year-and-a-half of preparation, an extensive survey of natural resources in the United States was transmitted to President Truman. This study, popularly known as the Paley Commission Report,[1] undertook the difficult task of assessing the future resource needs of the American economy and the resiliency of our resource base. The background for this inquiry—record material production during World War II followed by uneasy peace—determined the major question of the inquiry: Are our resources adequate to meet the requirements of national security and at the same time promote normal economic growth? Although President Truman's outline of the scope of the investigation was sufficiently broad to justify the study of almost any part of the economic system, two main areas were emphasized: (1) the relationship between long-run materials requirements and future supplies, and (2) the resource programs and policies of governmnt and private industry.

IN ITS APPROACH to the resource problems of the future, the Paley Commission selected 1900 as a point of departure and 1975 as a reasonably distant goal for projection. It finds the first half of the 20th century to be a period of impressive growth for the American economy: population doubled, normal output increased five-fold, and per capita income rose from approximately $325 in 1900 to $864 in 1950 (both years converted to 1939 dollars). Total consumption of all kinds of agricultural products increased two-and-one-fourth times, while our use of minerals rose to six times that of 1900. But such aggregates conceal the important changes that have occurred within the raw material component during this period of rapid industrialization.

We used two-and-one-half times more bituminous coal in 1950 than in 1900, but thirty times more crude oil; three times more copper and twenty-six times as much natural gas. Only in the case of "forest products" was there a perceptible decline, and even here an overall reduction of wood utilization by one per cent can hardly justify complacency since we are currently harvesting saw-timber at a rate that is forty per cent faster than annual growth. So with the most basic of our renewable resources—soil and water—we have exploited them vigorously and effectively, but frequently without full realization that the power to destroy is implicit in our ability to produce. In short, the United States has used its resources at a much greater rate than the rest of the world; we have less than ten per cent of the free world's population and only eight per cent of its land area, but consume close to half of the free world's total material output.

The transition from describing the past to forecasting the future is hardly as smooth and simple as the projection of the statistician's trend line. It involves assumptions that are frequently both heroic and arbitrary, and sometimes produces results that are as inaccurate as they are arresting. Two variables in particular, population growth and technological innovation, cause trouble for forecasters—population becaues of its recent erratic behavior and technology because of the seeming impossibility of discovering any pattern for predicting such change or assessing its economic significance prior to actual introduction. But both of these imponderables are of counter-vailing importance in the Commission's study since population affects directly the size of the labor force and the demand for output, as well as the kinds of products produced, while technology prescribes standards of raw material utilization and alternate processes that can be substituted for depleting resources. Because both sides of the resource balance sheet are affected by population and technology, statistician's projections at best represent an imperfect image of the future.

The Bureau of Census' prediction of twenty-seven per cent population increase by 1975, and a similar change in the labor force, provides the Commission with its fundamental statistic. From this estimate it concludes that gross national product will increase by 100 per cent by 1975 and that by this time the United States will have "outgrown" its resource base in non-food raw materials. Specifically, if the next twenty-five years follow the pattern established during the first fifty of this century, we will have moved through a period of production "surplus" of 15 per cent in 1900, a production "deficit" of nine per cent in 1950, to a projected production "deficit" of 20 percent in 1975—indicating primarily increased dependence upon foreign raw material supply. In other words, the unique position the United States held among industrial nations during the first half of the 20th

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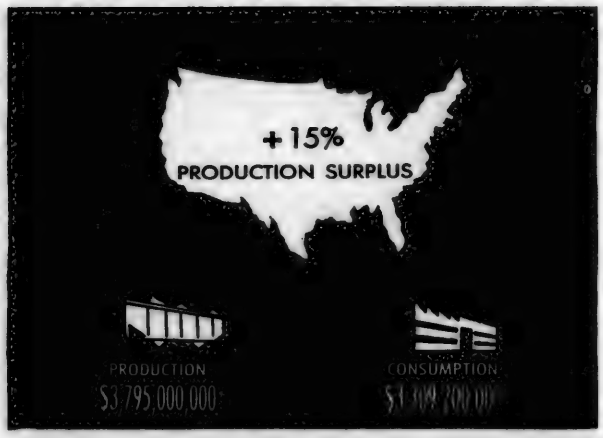
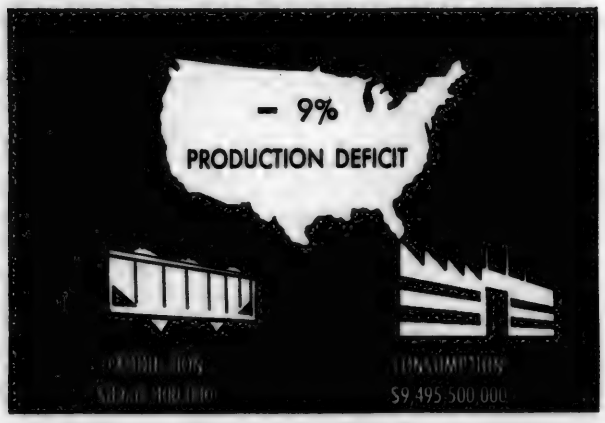
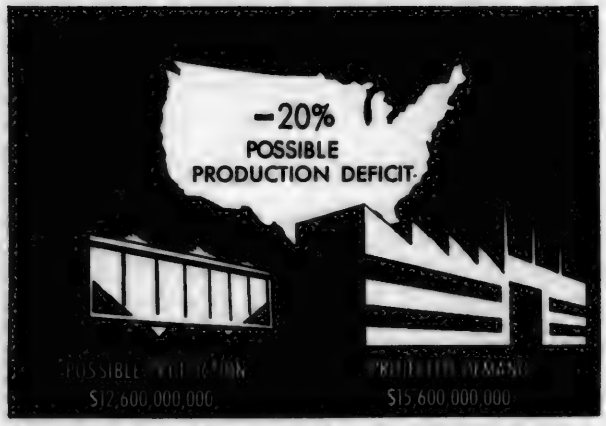






Source: Resources for Freedom, The President's Materials Policy Commission.

century has been altered. It is no longer simultaneously the world's largest producer of manufactured goods *and* the largest net exporter of raw materials. The pace of American industrialization—stimulated by abundant natural resources, a productive, growing population, and unusual technological innovation—has so outstripped the rest of the world that we are forced to draw upon foreign resources to maintain our normal economic growth of three per cent per year.

Water Shortage and Misallocation

Increasing dependence on foreign raw material supplies attests the rapid utilization of some American exhaustible resources and foreshadows greater strain upon our renewable resources. For example, conservation of water—one of the prime natural resources of agriculture and industry—poses one of the most difficult policy problems for our nation during the years immediately ahead. Virtually all the factors that complicate the determination of public policy are involved in this problem: regional disparity in water supply, articulate special interests, jurisdictional conflicts, and steadily mounting demand for water for all uses. Contrary to popular belief, the need for water conservation is not limited to areas of regional maladjustment in water distribution or supply, but involves three distinct but interrelated problems: *(1) the allocation of water resources to different uses; (2) the overdraft of water in selected areas; and (3) the pollution and inadequate recycling of water in most regions.*

Although acute water shortages accentuate all of the above water conservation problems, perhaps the most important effect of such shortages is the new dimension that is added to the problem of national water supply allocation. As long as water is sufficiently abundant to satisfy all demand—manufacturing, urban expansion, and agricultural growth—no allocation problem is encountered. But when scarce water resources are diverted from more valuable uses to increase agricultural output that could be produced on eastern lands without irrigation, a serious misallocation of resources follows, which affects not only water but land utilization, location of industry, and community development. The undesirable effects of such misallocation increase in direct proportion to population growth and economic development. Basing its judgment on the conclusion that water consumption for irrigation is from five to ten times as great as for manufacturing, and that manufacturing output per unit of water is roughly fifty times more valuable, the Commission seriously questions the economic feasibility of greatly extending irrigation in some western areas.

Irrigation is also largely responsible for the nation's greatest overdraft of ground water. Approximately five billion gallons per day overdraft in the southwest, in addition to raising the problem of optimum resource allocation, may cause irreparable injury to ground water sources in this region. Overrapid removal of ground water in such regions if continued may permanently impair the capacity of the area to maintain future farm output. In short, lack of proper management is chang-

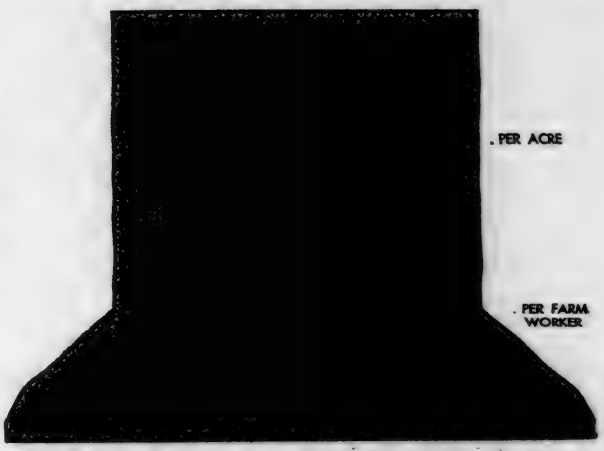
ing an important renewable resource to the status of an exhaustible resource.

Along with the overdraft of ground water for irrigation, heavy pollution of surface and ground water and indifference to recycling are unfortunate characteristics of American water policy. Urbanization and new developments such as air conditioning have already strained some local water resources, while new industrial processes are notorious water users. For example, the manufacture of nylon and rayon requires much larger quantities of water than did the processing of the materials they replaced, and each additional stage in oil refining demands increased water capacity. At the same time new domestic and industrial water uses impair important ancillary uses of water and shift the costs of pollution and decreased water supply to the public unless rigorous controls are imposed.

Pollution is one of the major water conservation problems that is more or less generally encountered throughout the United States. According to the Public Health Service, there are approximately 22,000 major sources of water pollution in the United States, with responsibility almost equally divided between municipalities and private industry. To achieve a reasonable degree of pollution control over the next ten years, the Commission estimates that an expenditure of between nine and twelve billion dollars will be required under a program complicated by jurisdictional rivalries between federal, state, and local agencies. Because of the special difficulties involved in water control, the Commission is skeptical of the likelihood of success of the Water Pollution Control Act of 1948, which attacks the problem through pollution hearings, Congressional approval for interstate anti-pollution compacts, and Federal loans and grants for pollution elimination. The Commission suggests that this legislation be strengthened by increasing the power of the Federal government through the passage of a sumptuary tax on industrial operations that pollute navigable waters and interstate streams, along with an expanded Federal program of research on pollution elimination and grants to lower units of government to encourage improvement.

Future Food and Fiber Needs

If the Bureau of Census' estimate of a population of 193.4 million by 1975 and the Commission's forecast of gross national product of approximately 547 billion dollars are correct, we can expect an increase in personal disposable income of roughly fifty-four per cent. On the basis of past consumption patterns, which may not be reliable indicators of future trends, a forty-two per cent increase in total food consumption is anticipated by 1975, along with an expected increase of twenty-five per cent in non-food use of agricultural products. As a working hypothesis, the Commission assumes that a net forty per cent increase in all agricultural products will meet both food and non-food demand by 1975. It further believes that farm output can be raised to the desired level by 1975 through wider application of fertilizer and technology to increase crop and livestock yield per acre, plus shifting land already within the industry to more productive farm use. The Commission suggests that approximately 100 million acres of grass and woodland not currently in farms could be employed for crop rotation if necessary, but feels that generally the extension of known techniques (such as wholesale introduction of hybrid seeds, use of antibiotics, and increased fertilizer applications) will raise the yield of existing farm land to the extent required by our growing population and expanding economy.



Source: Resource for Freedom, The President's Materials Policy Commission.

As a result of the growth of population and industrial expansion, approximately fifteen million acres of farm land will be lost to airport development, roads, residential dwellings, and the like, which must be replaced by land from forest, reclamation, or similar sources. In addition, the Commission considers the following shifts in farm land allocation essential to meet the future requirements: (1) approximately forty million acres of crop land are subject to such serious erosion that they should be converted to permanent grassland or woodland; (2) ten million acres of woodland pasture should be cleared to permit more productive use through rotation between crop and pasture; and (3) about eighty million acres of permanent pasture should be improved to a point where this land can be rotated between pasture crops.

For the individual farm unit the goal of forty per cent increased output by 1975 will require, in addition to the adoption of modern land practices and up-to-date technology, a moderate increase in farm equipment and

(*Continued on page* 243)

Pacific Coast Reports Progress in Using Power for Soil Sampling

LEONARD R. WOHLETZ AND FRED A. HOUGHTON, JR.

Soil surveyors long have sought a power-driven auger for general use in the field—one which would work effectively under a wide variety of circumstances. Many have been designed and tested. Some have been sufficiently successful to arouse the enthusiasm of their designers and adherent. One such auger, which was built and tested in Southern California, has led to the purchase of several more. These currently are being used on soil surveys in all sections of the state. While this design may not be the final answer, the story of its development and field testing should be of interest to all concerned with expediting soil surveys in the United States.

THE PROBLEM of sampling soil under a wide variety of field conditions has been present with scientists ever since they began studying soils. To sample some of the earliest soils, men modified a large-size carpenter's wood bit and extended the handle to make what is known as a worm-type soils auger. The type that was next developed is called the orchard-type auger. This implement has a bucket three to four inches in diameter and about a foot long, within two dog-ear shaped bits which load the barrel with the sample being taken. The auger has proven effective under a wide variety of soil conditions. The King Tube type soil sampler has been of little use for soil mapping because rock, gravel and hard dry soils tend to make this implement rather impractical. Currently, an auger brought over from Holland called the *"Dutch Mud Auger"* is being tried in California. This auger has shown considerable promise for sampling heavy wet soils.

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Power Needed

There has long been a need and a desire on the part of soil scientists to develop power equipment which would adequately sample the soil, be easy to operate and sufficiently mobile to get over the land. About three years ago, a pilot model of such an auger was developed at San Fernando by Fred Eggers, survey supervisor, and Vic Stone, mechanic, of the Soil Conservation Service in cooperation with the Portable Earth Auger Company of San Bernardino, California. This satisfies many of our needs. This auger consists of a conveyor-type 5-foot auger powered by a small 3½ h.p. gas engine. As originally manufactured by the Portable Auger Company, this auger is provided with handles requiring two men to hold the unit when in operation. It does a very satisfactory job of digging post holes for which it is designed.

Figure 1.—*Left.* Sampling soil with a hand auger is a tedious, time-consuming job. *Right.* An early attempt to use a mechanical soil auger, developed by the Portable Earth Auger Company, San Bernardino, California, for soil sampling. This design is powered with a 3½ h.p. gas engine and has an automatic safety clutch. Although the tripod and block and tackle were not practical for our purposes, this was the starting point in the modifications to follow.

Figure 2.—A capstan was added, designed to lift the engine and auger by power. The lift is secured from friction of the rope around the capstan. A light pull on the tail rope causes the rope to grip the turning capstan and run in rope which lifts the entire power unit and bit; to stop the lift, the tension on the tail rope is decreased and the rope slips around the capstan; to lower the unit the tail rope tension is decreased further and gravity takes over. Stability against torque is obtained from the two pipe guides.

Early Modification

The first modification, which made it more suitable for our work, was to add a "capstan," powered from the motor, to provide power to life the auger on an "A" frame mounted in the bed of a pickup. The unit was stabilized by two pipe guides suspended also from the "A" frame. It was designed for and found to be very satisfactory in digging holes to a depth of five feet. This power auger is mounted on a conventional pickup or a 4-wheel drive Willys pickup, depending upon the nature of the soils and terrain to be surveyed. The conveyor-type bit is quick and efficient in digging a hole. However, the soil sample obtained is rather poor as the soil horizons are somewhat mixed. It has proven to be the unit most useful to verify the presence or absence of limiting subsoil conditions, such as claypans, hardpans, or gravel. A few holes with other type bits are necessary to completely sample the soil. It has been most successful on dry farm grain lands, range areas and similar locations where digging is difficult and where 5-foot depth of soil sampling is sufficient.

Greater Depth Needed

Difficulty was experienced when this rig was used in an attempt to make soil borings in heavy poorly drained soils to depths exceeding the length of the original auger (about five feet). It was tedious and impractical to extend the depth by adding extensions to the auger. Each time an extension was added or removed it was necessary to hold the auger with its contained soil while the change was being made.

Recently Charles Morris and Lewis Leifer, soil scientists, were faced with the problem of mapping substrata conditions to ten feet in depth for drainage investigations in the Firebaugh Soil Conservation District. The soils of this area are generally heavy in texture and quite wet below five feet. This made digging holes with a 10-foot hand auger of any type slow and tedious. About the best they could do was to dig one hole an hour, working as a two-man team. After considerable discussion with the members of the area office, the following modifications of the power auger were made for sampling heavy wet soils to a depth of ten feet:

A platform was constructed out of wood for this trial model. The platform is of such dimension that it fits

Figure 3.—The first production model (EX-D) in operation with a 6" conveyor-type bit. This rig is satisfactory for determining the depth to easily recognized subsoil layers such as claypan, hardpan or parent rock.

Figure 4.—*Left.* A platform of wood to fit in a pickup bed was constructed to provide a deck four feet high for mounting the "A" frame. Through a simple extension of the guide pipes, a working height of ten feet was obtained. *Right.* The entire framework folds into a pickup bed or down on the platform (shown here) for road travel. The derrick is quickly erected on arriving in the area to be mapped and is left in this position until time to return home.

in the pickup bed and provides a deck four feet above the floor of the pickup. It is constructed of 4″ x 4″ and 2″ x 12″ stock, with water-proof plywood gussets on the corners to provide rigidity. The "A" frame of the auger is mounted on the platform which, with longer pipe guides, provides a working height of ten feet. The motor is accessible by standing on the raised platform.

The problem of sampling heavy texture wet soils was solved by using a 1¾-inch worm auger made from a modified carpenter's bit. This was attached to a ¾-inch pipe of sufficient length to sample ten feet. With the motor providing power, a 4- to 10-inch increment of the soil profile can be taken and quickly hoisted out of the sample hole. After the sample has been lifted, a shovel is laid over the hole to prevent material from falling back into the hole. The sample is then removed and the auger is allowed to drop back into the hole and the operation is repeated. Occasionally, with heavy compact moist soil, it is necessary to use the point of a shovel in the worm to remove the soil sample.

Increases Rate of Soil Sampling

Using this equipment, Leifer and Morris are able to sample four or five locations per hour to a depth of ten feet per hour. In one 4-hour period they were able to make sixteen 10-foot sample holes. Under conditions of heavy wet soil, needing 10-foot sampling for drainage design, sufficient money would be saved in digging 300 holes to purchase the power auger and modify it for deep operation. (Figure two men—one GS-7 at $2.02 per hour and one GS-2 at $1.32 per hour; then a hand-dug hole at one hole per hour would cost $3.34 and a power-dug hole at four holes per hour would cost $0.84, or $2.50 would be saved on each hole.)

The soil profile information obtained with this power auger is very accurate as there is no mixing of the sample with materials scraped from the side of the hole. The depth of texture changes is easily determined as each sample is only 4- to 10-inch depth increment. This equipment has been tried also with an "orchard" type auger. The orchard-type auger works very well in dry to moist soils that do not stick to the wall of the barrel. These two augers (B and C in Figure 7) can quickly and

Figure 5.—The complete unit with the "A" frame erected ready to take soil samples to depth of ten feet. Two men work most effectively. One man operates the power unit which takes the sample and lifts it out of the hole. The second man removes the sample from the bit and records the information. The 1¾ inch bit shown here is best suited for sampling heavy wet soils.

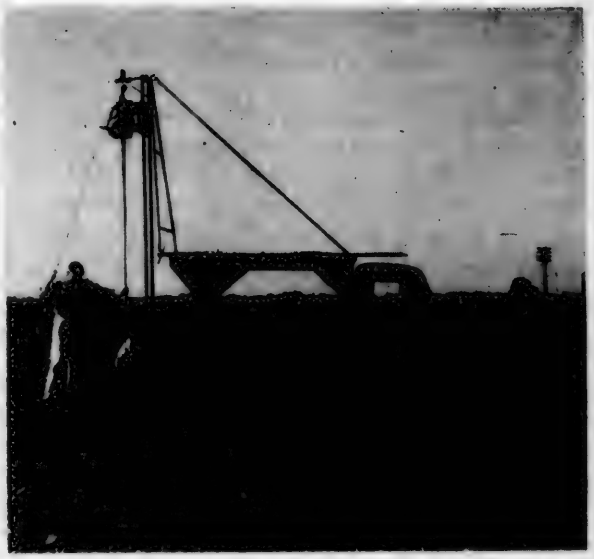

Figure.6—The entire power unit with the attached shank and bit move up and down the pipe guides. When the motor was stopped for this picture the soil had been sampled to a depth of seven feet six inches. For this deep work in heavy wet clay it was found desirable to add another pulley and increase the mechanical advantage at the capstan from 2:1 to 3:1.

adequately sample all except the very gravelly and stony soils. The conveyor-type auger 6" in diameter works best for 5-foot borings in the gravelly and stony soils.

It is realized that deep sampling is slow and is only justified where it is necessary. When operating under conditions where only five foot sampling is needed, the platform can be removed and the long guides replaced by the short guides of the original unit. Two men can do this in about one hour.

Costs are Nominal

The cost of the Ground Hog Power Auger, Model EX-D, for 5-foot sampling is about $650. With the investment of around $100, the modification for 10-foot sampling can be made. This power auger with its modifications is not the ultimate in soil sampling but is a step in the right direction. Some difficulty is encountered in regulating the rope friction on the capstan in moist weather. An improved system (possibly hydraulic) for raising and lowering the auger is being investigated. As presently designed, the auger pays for itself in a short time when properly maintained and used in areas having soils problems adapted to its use. The several types of

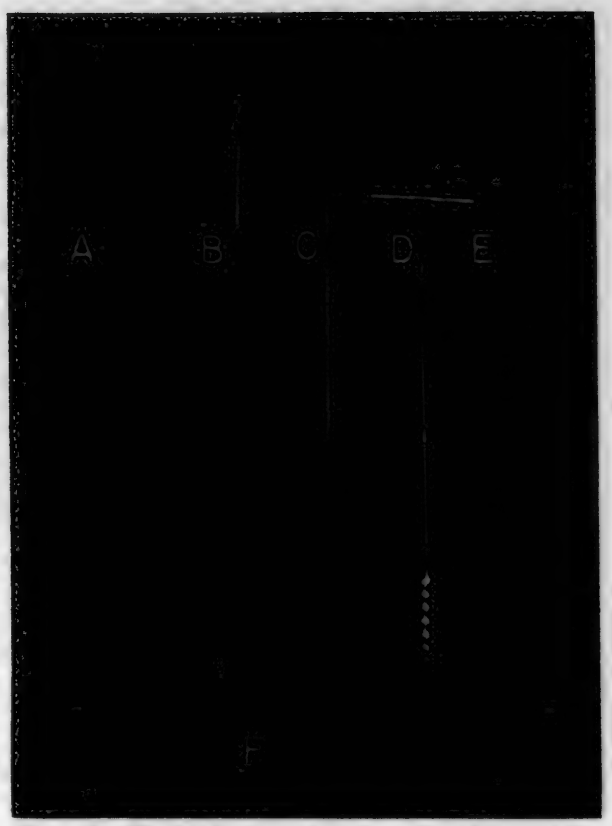

Figure 7.—The bit best suited to the soil to be sampled is selected. Those usually carried with the modified unit are:

A—6" diameter conveyor-type bit power operated for hard, dry and gravelly soils.

B—7' shank with a 4" bucket power operated for deep sampling of hard, dry and gravelly soils. Note the foot markers of masking tape on the shank.

C—7' shank with a 1¾" modified carpenter's wood bit power operated for deep sampling of heavy textured wet soils

D—5' worm-type auger for hand operation. (This auger breaks down to 1-foot lengths).

E—5' orchard-type auger with 3" bucket for hand operation.

F—3' extension shank for adding to B or C to sample 10-foot depths with power.

auger bits must be kept in good condition and switched around to fit the soils involved.

The first power auger of this type has been in operation over two years and only minor repairs of nominal cost have been required. The Soil Conservation Service now has seven of these power augers in California. Only one has been modified for deep 10-foot sampling. Others will be modified as the need develops.

Upstream Floodwater Damages

ERWIN C. FORD

Public interest in the conservation, development and use of our land and water resources has never been greater. Over the years, the need for controlling, conserving and using wisely the water resources of the nation has become more pressing. Part of this development was passage of the Flood Control Act of 1936 which recognized flood control as a Federal activity in the National interest. Floods, like death and taxes, are no respecter of persons, and because floods affect all of us either directly or indirectly the reduction in the heavy toll of damage from this cause is of vital concern to every citizen of the Nation.

MOST PEOPLE THINK of a flood in terms of newspaper headlines or in the language used by the president in a message to the Congress regarding the 1951 Missouri River flood:

> *"A great flood disaster—one of the most terrible in the history of the United States—has struck a vast area of the Middle West. . . . . The loss to the Nation along 1,000 miles of river valleys is now been measured. Already more than $1,000,000,000 in physical damage and at least that much more in loss of income has been counted in preliminary estimates. When the final estimate is in, the toll will be greater."*[1]

This was, indeed, a great flood and a disaster of the first magnitude.

Less spectacular are the many floods that occur year after year within the tributary headwaters of our major rivers but they cause much larger total damage. These floods in the aggregate cause an average annual damage of approximately $545,000,000[1] according to preliminary estimates based on a study of some 77 watersheds. These watersheds cover an area of approximately 52 per cent of the continental United States (table 1). In the areas affected these floods mean damaged, destroyed or washed out crops, damaged homes, eroded lands and frequently the loss of a lifetime of work. Thus, a relatively high percentage of all floodwater damage is caused by floods on headwater streams.

These floods on creeks and small tributary streams are usually caused by short intensive storms which cover relatively small areas. Such floods occur far oftener than the storms of longer duration over large areas which are required to produce a main stem flood. A high proportion of headwater flood damages are occasioned by floods that occur more frequently than once in 10 years. Because of the thousands of headwater streams which drain our vast agricultural regions it can be seen that the damage caused each year by many frequent floods will build up to a staggering total.

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Annual Flood Damages

In the headwater valleys a major part of the average annual flood losses are predominantly agricultural. Percentage-wise, the figure will approximate 70 per cent of the total average annual damage (table 1). This loss includes crops and pasture and other agricultural items, such as damage to fences, roads, buildings, stored crops, livestock. Land damage in the form of floodplain scour, streambank erosion, gullying and valley trenching though not so important momentary-wise as the types of damage described above, is quite important from the standpoint of our agricultural resources. Some 5 per cent or more of our total agricultural land lies in the alluvial flood plains of tributary valleys. This land on the average is the most productive that we have. If given flood protection of a reasonable degree it will remain productive for a long time to come. Some land damage is somewhat temporary in nature in that full productivity can be restored within a relatively few years.

In other cases the damage is more or less permanent and productivity is impaired for future generations. It therefore seems highly important that protection from land damage should be one of the first essentials in our attack on the flood-damage problem.

For the nation as a whole, preliminary estimates indi-

Table 1.—Estimated Average Annual Upstream Floodwater Damage in the United States, by Types[1]

Type of Damage	Dollars[2]	Percent of Total
Crops & Pasture	$239,180,000	43.9
Other Agricultural	84,875,000	15.6
Land Damage	36,590,000	6.7
TOTAL AGRICULTURAL	360,645,000	66.2
Transportation Facilities	50,675,000	9.3
Urban Property	40,596,000	7.4
Industrial, Commercial & Other	27,176,000	5.0
TOTAL NONAGRICULTURAL	118,147,000	21.7
Indirect	66,030,000	12.1
GRAND TOTAL	545,122,000	—

[1]Based on prices for the year ending July 31, 1952.
[2]Preliminary.

cate that the average annual upstream floodwater damages to nonagricultural property amounts to roughly $118,000,000. These consist of damages to transportation facilities, industrial, commercial, and other urban property.

In addition to the damages enumerated in Table 1, it is estimated that some 66 million dollars worth of indirect damages occur annually. These result both from the direct agricultural and nonagricultural damages. In general they represent loss of income in the processing of agricultural products, loss of trade from areas that suffer damage, delays in transportation, and many other forms of indirect monetary loss.

It is estimated that the average annual flood damages in the major river valleys is about 500 million dollars. (2) These damages, unlike those occurring in the headwaters of streams, are predominantly nonagricultural. This is significant because it again points up the fact that floods and their damaging effects concern all the people, whether they are urban or rural residents.

On the basis of these estimates, the total average annual floodwater and sediment damage in the United States approximates $1.2 billion. Of this total about $677 million, or 56 per cent, is upstream headwater damage and $528 million, or 44 per cent, downstream major river damage. Thus, a comparison of the headwater damages with downstream damages indicates two major flood problems: the problem of reducing headwater damage and the problem of providing protection to the heavy concentration of wealth and population in the great river valleys. In both cases the highest possible degree of protection from floods should be given so long as such protection is economically justified.

Basis for Flood Damage Estimates

In estimating upstream floodwater damages, the nation was divided into seven geographic areas, Figure 1, and estimates were made of the total upstream floodwater damage in each of these areas. The estimates were developed from intensive studies of actual flood occurrences, flood magnitudes and frequencies on sample watersheds located in many sections of the United States. Floodwater and sediment damage data from these sample studies were expanded to areas of similar physical and economic characteristics, in order to arrive at areawide totals. In some cases, the expansion could be made directly on an aerial basis, in others this was not possible, and in those instances other expansion techniques were employed in making the estimates.

In areas 1 and 7, nonagricultural damages exceed agricultural damages. In area 1, the nonagricultural damage will approach three times that to agriculture; and in area 7, about one and one-half times. The same situation does not obtain, however, for the other areas. In almost every case total agricultural damage will exceed the nonagricultural damage by a substantial margin. This is especially true in areas 2, 3, 4, and 5. In most of the geographic areas the damage to crops and pastures exceeds any other single type of damage by a considerable margin. Other agricultural damage usually ranks second in importance. For the nation as a whole, transportation-facility damage ranks third. The reason for this relatively high figure appears to be the unusually heavy damage which is often occasioned to roads, highways, railroads, bridges, pipe lines, telephone and telegraph lines. In some geographic areas figures were not available to allow making a breakdown of nonagricultural damage for such items as industrial, commercial and other. Usually these were included as a lump sum under "urban property damage."

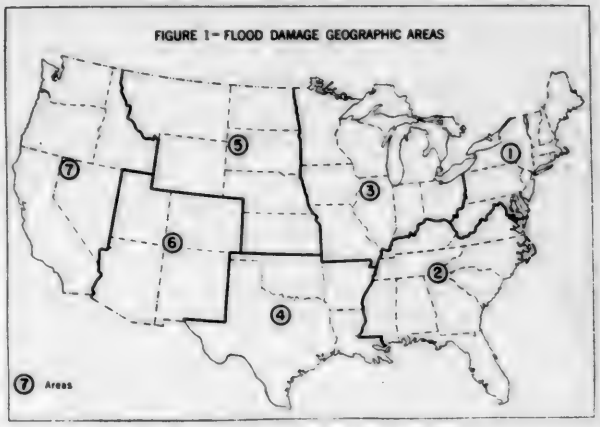

Figure 1.—Flood damage Geographic Areas.

Sediment Damages Significant

The damages shown in Table 2 are water damages only. It is virtually impossible, however, to separate purely water damage from that caused by a combination of water and sediment. Sediment frequently occurs in flood waters and it, too, contributes to the damaging effect. This can easily be illustrated by visualizing what would happen if a flood should cover a crop of wheat in

Table 2.—Average Annual Upstream Floodwater Damages, in Dollars, by Geographic Areas

Geographic area	Total
1	37,626,000
2	157,575,000
3	102,385,000
4	97,200,000
5	109,789,000
6	10,135,000
7	30,412,000
Total U. S.	545,122,000

the pre-harvest stage. Even a brief covering of the crop by the floor waters at this stage of growth is sufficient to leave a fine coating of sediment over the entire head of the plant. This coating seems to have the effect of stopping further growth of the plant and, of course, prevents maturity of the crop. This type of damage is called "floodwater and sediment damage," largely because the two are inseparable.

Certain types of sedimentation, however, may be clearly separated from strictly floodwater damage. These are often described in the following broad groups: (1) infertile overwash, (2) swamping, (3) filling of reservoirs, (4) damage to water-filtration facilities, (5) damage to transportation facilities, and (6) damage to drainage and irrigation facilities. Tentative estimates of this type of damage for the United States as a whole based on 1952 prices approximate 160 million dollars annually.

Sedimentation damage seems to occur most often in the cultivated farm land areas of the country, especially in geographic areas 2, 3, 4 and 5. Areas under cultivation are usually more subject than others to washing and to other forces of erosion. Erosion contributes a large load of sediment to the headwater tributaries and consequently to downstream and mainstream areas. Such sediment fills channels, is deposited on the highly productive floodplains, and is carried into major reservoirs.

In those areas where upland erosion is progressing at a rapid rate, serious damage often results from the deposition of this eroded material on the floodplain lands. After erosion has progressed to a certain point the material eroded from the uplands consists largely of sterile soil particles. Such deposits tend to make the bottom lands less productive and in some cases make the land practically worthless.

As later floods occur, the waters have a tendency to pick up and transport sediment farther downstream into major reservoirs, water filtration systems of cities, drainage and irrigation ditches and on to transportation facilities. Deposition of silt in ponds and reservoirs is extremely serious in many parts of the country, especially where rapid filling of the ponding area takes place. The life of water supply, power, flood control and other types of reservoirs is often drastically shortened by this filling.

Since damages from sedimentation, as described above, tend to be cumulative, anything that can be done to reduce the sediment content in flood waters is extremely important. Thus sediment that is brought down from the top of the hills into the little waters and the major river valleys will tend to produce damage in future years through decreasing the channel capacities, gradual destruction of the productive bottom land, and swamping of the bottom land and consequent raising of groundwater levels.

Another aspect of sediment damage is that done to navigation channels, especially to navigable rivers and harbors. Each year millions of dollars are spent in the United States in cleaning and dredging out such channels. Most of this sediment is caused by erosion on the uplands.

Flooding of residential property and other types of sediment damage quite often occur, especially in urban areas. Sediment deposits of several inches, which have often been ecountered in clean-ups after major floods, are costly to urban residents.

Under the 1936 Flood Control Act the Corps of Engineers was assigned the responsibility for investigations and improvement of rivers and other waterways for flood control and allied purposes. The Department of Agriculture was given the responsibility for investigations and improvement of watersheds for runoff and waterflow retardation and soil erosion prevention. Thus, there are two interrelated and coordinated parts to the total flood prevention and control job that needs to be done in this country. To fully carry out this job both upstream and downstream programs must be worked out in close coordination with each other if the best over-all program is to be designed and installed for the protection, conservation and development of our land and water resources.

In working out this complicated problem it is essential that Federal agencies should present to the local people and other interested groups all of the facts that are available. Such information will enable the people living within a basin to make the correct decisions after studying the facts and to participate in determining the best possible corrective program in the interest of the local people concerned and the nation.

More Emphasis on Watersheds Needed

Since about 56 per cent of the current average annual floodwater and sediment damage occurs in the valleys of headwater streams and since a large part of this damage is agricultural and primarily affects agricultural interests, it appears that additional emphasis should be given to upstream floodwater and sediment damage prevention.

Recent Federal appropriations have provided about $63 for flood control on main streams to every $1 for watershed flood prevention. There is urgent need for better flood damage prevention in headwater areas through a functionally interrelated three-fold program, each part given proper weight in terms of public assistance and coordinated with the others to the fullest degree possible. These are:

(*Continued on page 246*)

Consumptive Use of Water and Irrigation Requirements

(*Continued from page 212*)

Peak monthly use rate = 6 inches
Depth of application = 4 inches
Irrigation efficiency = 60 per cent

Then:

Peak daily consumptive use rate = 0.23 inches per day
Design rate = 0.38 acre inches per acre per day or a continuous flow rate of 7.6 g.p.m. per acre

Thus, if all the needs of the crop are to be met from irrigation water during the peak month, and if water cannot be applied at a higher efficiency than 60 per cent, it will be necessary to have a flow rate of 7.6 g.p.m. for each acre or 1 c.f.s. for about 60 acres of land assuming that irrigation would be applied on a 24-hour per day schedule.

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Resources for Freedom: President's Materials Policy Commission

(*Continued from page 235*)

buildings and substantially greater applications of commercial fertilizers. Somewhat over two-and-a-half times the four billion tons of plant nutrients used in 1950 will be required to raise the agricultural output to the desired goal by 1975. Although the increased use of commercial fertilizer during the past few years has averaged in the neighborhood of ten per cent per annum, the Commission does not expect this rate of increase to continue indefinitely. In recent years commercial fertilizer supply has not kept up with demand, and some difficulty may be encountered in expanding fertilizer output within a cost range that will continue to make increased applications attractive to the farmer. Moreover, in order to hold existing gains in land yield, an annual application of eighty million tons of liming material will be required. These are impressive goals, and will undoubtedly require an unusually effective educational program among the nation's farm operators. Fortunately the United States is largely self-sufficient in the three primary plant nutrients, nitrogen, phosphate, and potash, although increasing dependence upon western potash deposits may require electric furnace processing at somewhat higher cost.

The publication of the President's Materials Policy Commission Report comes at a critical stage of transition in the development of the United States, when the effects of the policies of government and business extend well beyond the confines of the domestic economy or the present generation. The Material's Policy Report, although sometimes rambling and uneven, represents a highly commendable attempt to establish guide lines to the future.

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[1]The President's Materials Policy Commission, RESOURCES FOR FREEDOM (Washington, D. C.: Government Printing Office, 1952, $7.00). The Report consists of five volumes, Volume 1: "Foundations for Growth and Security;" Volume 2: "The Outlook for Key Commodities;" Volume 3: "The Outlook for Energy Sources;" Volume 4: "The Promise of Technology;" Volume 5: "Selected Reports to the Commission."

The Material's Policy Commission was made up of William S. Paley, chairman, George R. Brown, Arthur H. Bunker, Eric Hodgins, and Edward S. Mason. The executive staff was under the direction of Philip H. Coombs, Norvell W. Page served as general editor, and over a hundred specialists contributed full or part-time work to the project. In addition, the Commission made use of the broad grant of authority from President Truman to call upon governmental agencies, private research organizations, and business firms for information and special studies.

The above article is limited to a brief review of the overall conclusions of the Report and selected soil and water conservation topics. Volumes 1 and 5 contain the major sources of material on these topics.

Book Reviews

SOIL SURVEYS FOR LAND DEVELOPMENT. *Edited by C. G. Stephens, Consultant (Soils) Land and Water Use Branch, Agriculture Division, Food and Agriculture Organization of the United Nations, Rome, Italy. 110 pages. Illustrated. Sales agent in U. S. is Columbia University Press, International Documents Service, 2960 Broadway, 27, N. Y. March 1953. $1.00.*

"Soil Surveys for Land Development" is a monograph compiled primarily for use by administrators and officials in charge of agencies such as agriculture, forestry, soil and water conservation, irrigation, drainage, land settlement, taxation, and civil engineering.

It is not a manual for making soil surveys, although it contains sufficient information on the techniques of soil mapping and classification to provide a basis for estimating cost of work, type of equipment needed, and methods of survey operations to guide officials in formulating and carrying out a soil survey program.

This monograph deals more specifically with the purposes and uses of soil surveys. It is intended to help show administrators in all countries that such an inventory can serve a wide variety of purposes. "In determining over-all agricultural policy it (an inventory of soil resources) may be used to show potential productivity of a country, delineate problem areas, indicate where and how production can be increased to meet emergencies, estimate fertilizer requirements of a country, distribute economically fertilizers in short supply, and to predict future agricultural populations, transport requirements and primary production so that harbor facilities, roads and other services can be planned to cope with future needs." Examples are given on the administration and development of soil survey programs in the United States, United Kingdom, Australia, Belgian Congo, the Netherlands, Canada, France and the French Union.

In addition to the above-listed countries, information on the work in South Africa, Belgium, New Zealand, India, Indonesia and Portugal was used in arriving at general conclusions with respect to features that characterize an efficient soil survey organization.

—R. D. Hockensmith, *Washington, D. C.*

CLIMATE, VEGETATION AND MAN. *By Leonard Hadlow. Philosophical Library, New York. 1953. 288 pages. Illustrated. $4.75.*

Leonard Hadlow, in this most fascinating book, tells how the material welfare of the various people of the world to a very large extent depends upon climate. In this connection, he points out that man's mental and spiritual development is, in part, controlled by the climatic environment in which he finds himself; also how in the course of history many civilizations have arisen and decayed with changing climatic conditions.

The book further covers the principles that govern day and night, the seasons and the world distribution of temperature, atmospheric pressure, winds, rainfall and ocean currents. Another section of the book relates natural vegetation to its climatic needs. The author also tells how climate governs the activities of man, which is probably one of the most intriging sections of the book.

The book is unusually well organized and written. It discusses, for example, climate and weather, temperature and its controls, pressure belts, why it rains, the movements of the waters, how climate helps to control vegetation and cold belts, and the various temperature belts. Each chapter is well illustrated with excellent photographs and charts. And finally, the author lists a series of pointed questions at the end of each chapter to further interest and help the reader.

This is the kind of book that conservationists and others working in the field of agriculture will find helpful in many ways—especially as interests apply to droughts, floods and climatic conditions troubling man in his fight to conquer the elements.

—Walter C. Gumbel, *Fairmont, West Virginia*

WORLD RESOURCE STATISTICS. *By John C. Weaver and Fred E. Lukermann. Burgess Publishing Co., Minneapolis 15, Minnesota. 1953. 166 pages. $4.00.*

Compilers of statistical handbooks face a welter of related problems: what areas to cover, what sources to rely upon, how extensive to make the collection, and the like. At every step of the way, careful and judicious editing is required to maintain proper proportions among the topics and to prevent the handbook from growing beyond a convenient size. The fear of slighting a given subject frequently leads to the inclusion of marginal material in such works which reduces their usability.

Weaver and Lukermann of the Geography Department of the University of Minnesota have exercised nice choice and editorial restraint in the selection and treatment of their material. Drawn largely from specialized statistical reports of the United Nations and the United States Government, this handbook frequently excells the original sources in clarity of presentation and synthesis and collection of the material. It is an extremely useful desk reference for United States and world statistics on "population and land resources," "agricultural crops and livestock," "forests and fisheries," "metallic and nonmetallic minerals," "sources of power," and "industry and world trade."

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Here are some of the Program Highlights

Thursday, November 5

Natural Resources Conservation in a Capitalistic Economy—SHERMAN ADAMS, *Assistant to the President of the United States, Washington, D. C.*

Man's Impact on the Nation's Renewable Natural Resources—HARRELL DE GRAFF, *School of Nutrition, Cornell University, Ithaca, New York.*

Native Perennial Vegetation and Good Land Use—*Panel:* DR. R. E. MCARDLE, *Chief, U. S. Forest Service, Presiding. Members:* DR. WM. R. VAN DERSAL, *SCS, Oregon, Leader;* CHESTER J. OLSON, *F.S., Utah;* STANLEY A. CAIN, *University of Michigan;* DR. J. W. SEVERY, *Montana State University and* OLAUS MURIE, *Wyoming. (Others to be selected.)*

Irrigation and Water Use as Related to Watersheds—L. D. LOVE, *Rocky Mountain Forest and Range Experiment Station, Colorado.*

Annual Meeting of Chapters—H. WAYNE PRITCHARD, *presiding.*

Friday, November 6

Native Perennial Vegetation in the Economy of Western Canada—E. S. FELLOWS, *Chief Forester, Eastern Rockies Conservation Board, Alberta, Canada.*

Soil and Water Conservation in Western Canada—L. B. THOMPSON, *Prairie Rehabilitation Adm., Saskatchewan, Canada.*

Irrigating and Reclaiming Desert Land in Peru—DR. RENATO ROSSI, *Lima, Peru.*

Management of Native Perennial Vegetation for Livestock Production and Multiple Use—*Panel Members:* DR. R. PRICE, *Director, Southwestern Forest and Range Experiment Station, Leader;* MONT SANDERSON, *Range Consultant, Montana;* P. D. HANSON, *Regional Forester, Montana;* LINCOLN ELLISON, *Inter-Mountain Forest and Range Experiment Station, Utah and* F. G. RENNER, *Soil Conservation Service, Washington, D. C.*

Annual Banquet—*Speaker to be announced.*

Saturday, November 7

Findings of Technical Committees—DR. E. H. GRAHAM, *Soil Conservation Service, Washington, D. C., General Chairman, Presiding.*

Land Classification Committee, S. W. Crosby, Regional Soil Scientist, Soil Conservation Service, Portland, Oregon, Chairman.

Technical Standards Committee, Alfred M. Hedge, Soil Conservation Service, Washington, D. C., Chairman.

Crimson Clover Die-Out Committee, T. C. Maurer, Soil Conservation Service, Spartanburg, South Carolina, Chairman.

Wetland Management Committee, Frank C. Edminster, Soil Conservation Service, Upper Darby, Pa., Chairman.

Watershed Management Committee, Orville Chinn, Director, Division of Flood Control and Water Usage, Dept. of Conservation, Frankford, Ky., Chairman.

Gaining Public Understanding and Support for Renewable Natural Resources Conservation—RICHARD L. WEAVER, *Conservation Education, Ann Arbor, Michigan.*

Community and Agency Teamwork in a Montana Valley—HAROLD HAGEN, *Soil Conservation District Supervisor, Stevensville, Montana.*

Field Trip—*Details to be announced.*

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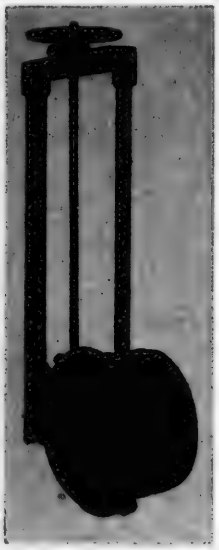

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SOIL SCIENCE SIMPLIFIED. *By* HELMUT KOHNKE, *West Lafayette, Indiana, Published by the author; 66 pages; 1953.*

Dr. Kohnke says his little booklet was prepared to give an understanding of the nature and behavior of soils to all who want to become acquainted with the soil without taking the time to do extensive reading. The booklet has only 66 pages, and the author has placed in it the important facts on physical, chemical, and biological aspects of soil, soil-water relations, and soil-plant growth relations. There are, in addition, concise informative chapters on soil classification, soil erosion, soil and crop management, and soil conservation. The author had to be very brief and at times resort to rather broad generalizations to condense so much material into 66 pages. He succeeds, however, in giving a quick overall picture of the subject. His presentation is clear and well organized with numerous tabular listings and diagrams.

Soil Conservationists and others will find *Soil Science Simplified* interesting and useful. It gives a short course in modern soil technology in quick readable form.

—ARNOLD J. BAUER, *Ithaca, New York*

PLOUGH AND PASTURE: THE EARLY HISTORY OF FARMING. *By* E. CECIL CURWEN and GUDMUND HATT. *Henry Schuman, Inc., New York 21, N. Y. 1953. 329 pages. $4.50.*

An important turning point in mankind's struggle for survival took place during prehistoric times with the start of corn growing in some region between Egypt and Mesopotamia. The slow and halting progress that followed over the course of many centuries, first with plowless agriculture, groping for useful plants, and gradually through domesticating animals and developing tools for cultivation, is traced down to the threshold of the machine age in this latest volume of the Life of Science Library.

The book is divided into two parts: "Prehistoric Farming of Europe and the Near East," by Curwen, and "Farming of Non-European Peoples," by Hatt. The first part by Curwen is reprinted with no major alteration from that author's *Plough and Pasture,* published in 1946 by the Cobbett Press of London.

Upstream Floodwater Damages

(*Continued from page* 242)

(1) *Land treatment.* Land treatment includes such measures as contour cultivation, terracing, improved rotations cover crops, improved range management, woodland management, and many others. Such measures, in proper combination, help prevent erosion, maintain soil fertility, conserve water by storing it in the soil, prevent damage on the farm from the erosive action of rainfall and runoff, and reduce the sediment loads of creeks and rivers. Land treatment measures are already being rapidly installed by landowners under the programs of the locally-organized soil conservation districts, aided by technical assistance from the Soil Conservation Service as well as by educational assistance and direct financial aids from others. The rate of application needs to be stepped up, however, to achieve more rapid protection of watershed areas.

(2) *Upstream waterflow retardation and channel stabilization.* This phase of watershed improvement, involving work on the tributaries and smaller waterways to control or retard runoff from neighboring farms includes measures such as small retarding structures, gully stabilization works and channel improvements, which are installed largely by contact, to alleviate damage to the agriculture and to rural improvements of the smaller watersheds above the downstream engineering works. These measures retard runoff and stabilize sources of sediment in upstream channels. They represent water-control operations over and above what is ordinarily

(*Continued on page* 248)

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Without rain there could be no food . . . no life on our planet.

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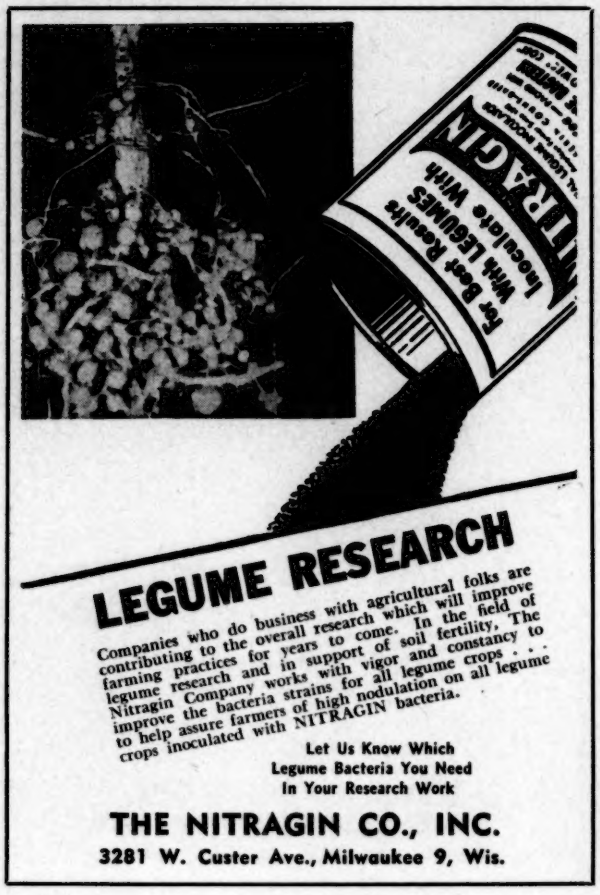

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Upstream Floodwater Damages

(*Continued from page* 246)

done through the farm-land conservation job. This type of work is carried out in a few watersheds by the Department of Agriculture, assisting local agencies and individuals.

(3) *Downstream flood-control measures.* Large reservoirs and levees constructed on the major waterways control flood flows in the major river valleys. Such measures alleviate urban and agricultural damages caused by major floods lower down the main rivers. This work is the responsibility of the Corps of Engineers.

This three-phase program is a coordinated approach to flood prevention and control—a program that protects the farmer or rancher of the uplands as well as of the lowlands, and the upstream bottomlands as well as the downstream cities.

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A New Stage in Resource History

(*Continued from page* 232)

tries in an effort to locate and focus research on major difficulties in meeting future materials needs.

5. Helping work out new local, regional and national administrative arrangements that will enable people to deal with multiple-uses of the land and at the same time preserve their integrity of individual action.

LITERATURE CITED

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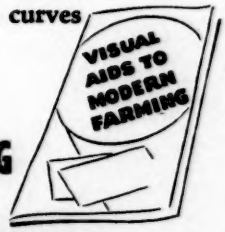

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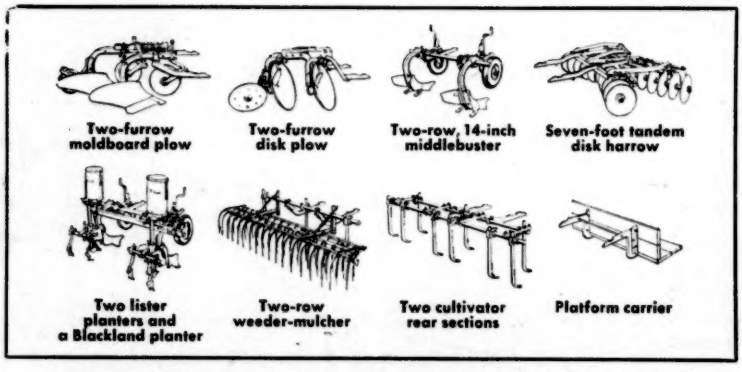

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